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DIVISION OF MINERAL RESOURCES
VIRGINIA GEOLOGICAL SURVEY
UNIVERSITY OF VIRGINIA
THOMAS LEONARD WATSON, PH. D.
DIRECTOR

Bulletin No. VI

Biennial Report

ON THE

Mineral Production of Virginia

During the Calendar Years

1909 and 1910

BY

THOMAS LEONARD WATSON

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Director of the Survey, and Professor of Geology in the University of Virginia

CHARLOTTESVILLE
UNIVERSITY OF VIRGINIA

1911



STATE GEOLOGICAL COMMISSION

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THOMAS LEONARD WATSON,
Director of the Survey.

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LETTER OF TRANSMITTAL

VIRGINIA GEOLOGICAL SURVEY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, October 20, 1911.

*To His Excellency, Hon. Wm. Hodges Mann, Governor of Virginia, and
Chairman of the State Geological Commission:*

SIR:—I have the honor to transmit herewith for publication, as Bulletin No. VI of the Virginia Geological Survey Series of Reports, a Biennial Report on the Mineral Production of Virginia during the Calendar Years 1909 and 1910, prepared by the Director of the Survey. In this report is given full information descriptive of the mining industry in Virginia during the calendar years 1909 and 1910.

Respectfully submitted,

THOMAS L. WATSON,

Director.

INTRODUCTION

Virginia is possessed of an abundance and variety of mineral materials. Many of these have been worked since early colonial days, especially the coal, iron ores, and brick clays. About 40 materials are now exploited, many of them on a large scale, which afford a basis of important commercial enterprises, and give to the State prominence in a varied and extensive mining industry. Most of the materials now produced can be developed still further with an increased production in future years. Some of these have been developed within recent years, and others still have not yet been exploited.

This bulletin gives full information descriptive of the mining industry in Virginia during the calendar years 1909 and 1910, including a brief treatment of the distribution, occurrence, development, and production of the mineral materials of the State. It has been prepared with the hope that it will be of service to those now engaged in exploitation of our resources, or otherwise interested in them. The statistics of mineral production in Virginia for the calendar year 1909 were collected by the Federal Survey in coöperation with the Bureau of the Census and furnished by courtesy of the Federal Survey to the Virginia Geological Survey. The statistics for the calendar year 1910 were collected by the Virginia Geological Survey in coöperation with the United States Geological Survey. The total number of productive operations is large, including a variety of subjects, as is indicated in the tables of annual production below. The aggregate value of their output in 1910, according to returns received at the State Survey office, amounted to \$22,755,161.

The statistics of production and value of the mineral resources of Virginia for 1909 and 1910 are given below in tabular form. The figures are well above the totals of most of the materials recorded in previous years. The increase in 1909 and 1910 over that of 1908 is especially noticeable in the large industries and in many of the smaller ones.

There are given in the tables below the production and value of the various mineral materials in Virginia for the years 1906 to 1910, inclusive.

Mineral Production of Virginia in 1906.

Product	Unit of Measurement	Quantity	Value
Barytes	Short tons	11,775	\$ 45,336
Clay	Short tons	2,903	24,354
Clay products			1,966,078
Coal	Short tons	4,254,879	4,183,991
Coke	Short tons	1,577,659	3,611,659
Ammonium sulphate	Pounds		
Coal tar	Gallons		
Gas, illuminating	Cubic feet		
Gas coke	Short tons		
Gold (mines report)	Fine ounces (Troy)	717.50	14,832
Iron ores	Long tons	828,081	1,579,817
Iron, pig	Long tons	483,525	^a 8,591,000
Lime	Short tons	104,486	382,083
Manganese ores	Long tons	6,028	77,522
Millstones			15,611
Mineral waters	Gallons	1,997,207	418,908
Precious stones			500
Pyrite	Long tons	128,794	431,388
Sand and gravel	Short tons	335,178	121,951
Silver (mines report)	Fine ounces (Troy)	250	168
Slate			172,857
Stone			606,343
Talc and soapstone	Short tons	23,624	590,800
Zinc	Short tons	1,143	139,446
Other products			^b 990,432
Total value.....			\$24,650,814

^aEstimated.^bIncludes asbestos, natural cement, Portland cement, gypsum, mica, ochre, pottery, quartz (flint), salt, sand-lime brick, and titanium.

Mineral Production of Virginia in 1907.

Product	Unit of Measurement	Quantity	Value
Barytes	Short tons	9,254	\$ 32,833
Clay products .....	.....		1,611,335
Coal	Short tons	4,710,895	4,807,533
Coke	Short tons	1,545,280	3,765,733
Ammonium sulphate	Pounds		
Coal tar	Gallons		
Gas, illuminating	Cubic feet		
Gas, water	Cubic feet		
Gas coke	Short tons		
Copper	Pounds	57,008	11,402
Glass sand	Short tons	1,246	4,535
Gold	Fine ounces (Troy)	402	8,300
Iron ores	Long tons	786,856	1,538,920
Iron, pig	Long tons	478,771	8,963,000
Lead	Short tons	82	8,692
Lime	Short tons	115,155	447,307
Manganese ores	Long tons	4,604	56,469
Mica .....	.....		1,014
Millstones .....	.....		4,684
Mineral waters	Gallons	2,442,075	431,770
Precious stones .....	.....		520
Pyrite	Long tons	124,740	372,586
Sand and gravel	Short tons	266,976	119,277
Silver	Fine ounces (Troy)	200	100
Slate .....	.....		173,670
Stone .....	.....		760,488
Talc and soapstone	Short tons	26,278	631,880
Zinc	Short tons	771	90,978
Other products .....	.....		a774,809
Total value .....	.....		\$25,783,656

aIncludes natural and Portland cement, feldspar, gypsum, ocher, rutile, and sand-lime brick.

Mineral Production of Virginia in 1908.

Product	Unit of Measurement	Quantity	Value
Clay	Short tons	442	\$ 3,250
Clay products			1,536,907
Coal	Short tons	4,259,042	3,868,524
Coke	Short tons	1,162,051	2,121,980
Ammonium sulphate	Pounds		
Coal tar	Gallons		
Gas, illuminating	Cubic feet		1,180,744
Gas, water	Cubic feet		
Gas coke	Short tons		
Copper	Pounds	24,775	3,270
Gold (mines report)	Fine ounces (Troy)	118.57	2,451
Granite			321,530
Iron ores	Long tons	692,223	1,465,691
Iron, pig	Long tons	320,458	4,578,000
Lead	Short tons	38	3,200
Lime and cement	Barrels	1,629,178	775,660
Limestone			280,542
Manganese ores	Long tons	6,418	63,324
Mica	Pounds (sheet)	13,427	
Millstones and sandstone	Tons (scraps)	46	7,346
Mineral waters	Gallons	a2,009,614	10,554
Pyrite	Long tons	116,340	207,115
Sand and gravel			495,522
Sand-lime brick	Thousands	6,181	119,095
Silver	Fine ounces (Troy)	236	36,934
Slate	Squares	41,678	125
Talc and soapstone	Short tons	19,616	194,356
Zinc	Short tons	705	458,252
Other products			66,315
Total value.....			b143,135
			\$17,883,822

aExclusive of 119,672 gallons used for soft drinks.

bIncludes barytes, feldspar, gypsum, mineral paint, and salt.

Mineral Production of Virginia in 1909.

Product	Unit of Measurement	Quantity	Value
Clay products			\$ 1,957,367
Coal	Short tons	4,752,217	4,251,056
Coke	Short tons	1,347,478	2,415,769
Copper	Pounds	224,162	29,141
Gems and precious stones			2,500
Gold (mines report).....	Fine ounces (Troy).....	181.41	3,750
Granite			488,250
Iron ores	Long tons	837,817	1,693,188
Iron, pig	Long tons	391,134	5,550,000
Lime	Short tons	166,695	635,946
Limestone			342,656
Mica			4,600
Millstones and sandstone			40,922
Mineral waters	Gallons	1,504,530	203,455
Pyrite	Long tons	114,176	423,283
Sand and gravel	Short tons	847,476	281,177
Silver	Fine ounces (Troy).....	4,825	2,509
Slate	Squares	40,880	180,775
Tale and soapstone	Short tons	26,511	523,942
Zinc	Short tons	58	6,298
Other products ^a			799,086
Total			\$19,835,670

^aIncludes barytes, Portland cement, feldspar, gypsum, manganese ore, manganiferous ore, ocher, rutile, salt, and sand-lime brick.

Mineral Production of Virginia in 1910.

Product	Unit of Measurement	Quantity	Value
Clay products			\$ 1,841,731
Coal	Short tons	6,507,997	5,877,486
Coke	Short tons	1,493,665	2,731,348
Copper	Pounds	5,402	686
Gold (mines report)	Fine ounces (Troy)	42.96	888
Granite			503,106
Iron ores	Long tons	903,377	1,845,144
Iron, pig	Long tons	414,976	6,150,000
Lead	Pounds	198,850	8,750
Lime	Short tons	141,257	563,567
Limestone			471,903
Manganese ores	Long tons	1,758	17,892
Millstones			5,273
Mineral waters ^a	Gallons	2,441,923	301,523
Pyrite	Long tons	140,106	525,437
Sand and gravel	Short tons	764,321	215,416
Silver	Fine ounces (Troy)	128	69
Slate	Squares	31,787	148,721
Talc and soapstone	Short tons	25,908	510,781
Zinc (spelter)	Pounds	1,588,112	85,758
Other products ^b			948,032
Total			\$22,755,161

^aExclusive of 48,252 gallons used in the manufacture of soft drinks.

^bIncludes barytes, Portland cement, feldspar, gypsum, infusorial earth, manganese ore, ocher, rutile, sand-lime brick, and salt.

PRELIMINARY GENERALITIES

GEOGRAPHIC POSITION OF VIRGINIA.

The State of Virginia is situated on the Atlantic slope of the Appalachian Mountains, halfway between Maine and Florida. It is included between the parallels $36^{\circ} 31'$ and $39^{\circ} 27'$ north latitude, and between the meridians $75^{\circ} 13'$ and $83^{\circ} 37'$ west longitude, extending from the sea-coast westward beyond the Great Valley to the Alleghany Front. The extreme length of the State from the Atlantic border to Kentucky is 476 miles, and the greatest width from north to south is 192 miles; its area is 42,450 square miles. Of this area, 2,325 square miles are covered with water, giving 40,125 square miles of land surface. Its principal inland waters are the Chesapeake and Mobjack bays, Hampton Roads, and Lake Drummond. Except in the eastern section, no navigable streams traverse the State, and transportation is necessarily limited to railways.

SURFACE FEATURES OF THE STATE.^a

Considered with reference to its surface features Virginia is divided into three major provinces: (1) An eastern plain region usually designated the Coastal Plain or Tidewater region; (2) a central or plateau region designated the Piedmont Plateau; and (3) a western or mountain region, designated the Appalachian Mountains province. The boundaries of these provinces are indicated on map, figure 1, page 8.

The three major provinces of the State differ markedly in the nature and origin of surface features, and in the age and kinds of rocks. They are intimately related to the geologic structure, and hence have an important bearing upon the mineral resources of the State. These are considered very briefly in order below.

^aA fuller discussion of this subject is contained in Bull. No. I-A of the State Geological Survey, 1909.

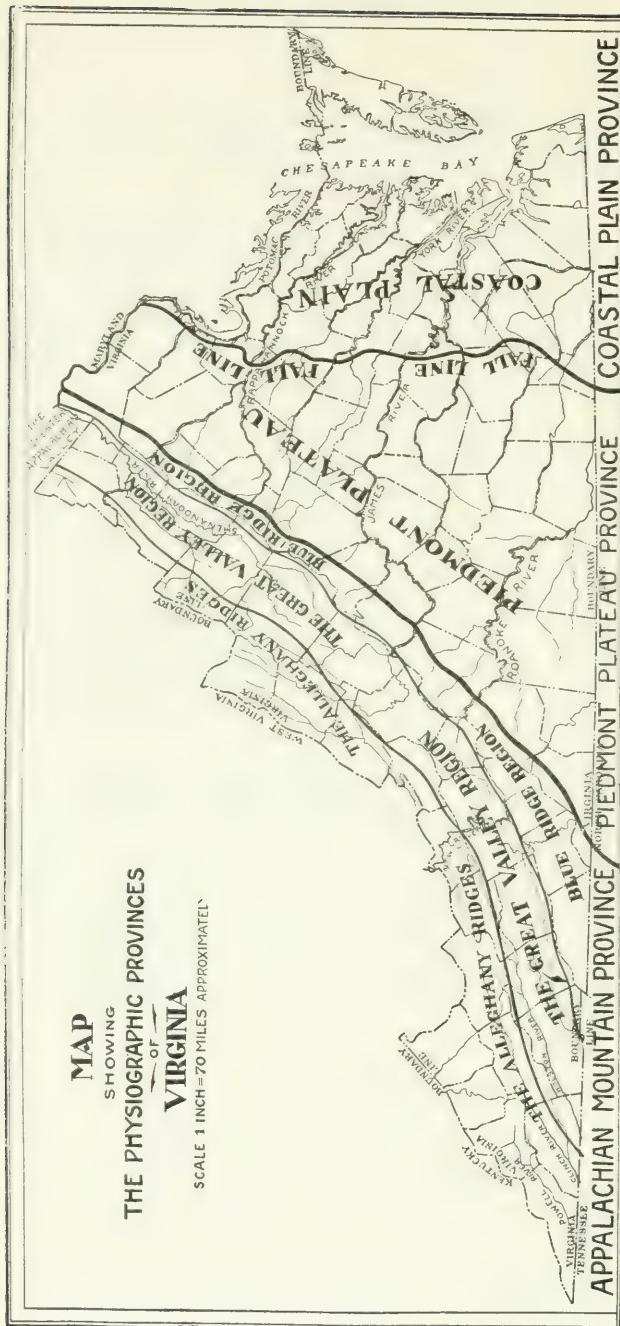


Fig. 1.—Sketch map of Virginia showing physiographic provinces.

The Coastal Plain Province.

The Virginia Coastal Plain province, the most easterly of the three larger physiographic provinces, and comprising approximately one-fourth of the total area of the State, is separated from the higher-lying Piedmont Plateau province on the west and the deep Atlantic Ocean basin on the east. The boundary of the Coastal Plain to the eastward is marked by the steep slope of the continental shelf, which lies from 30 to 50 miles east of the present shore-line. The western limit of the Coastal Plain is defined by the belt of metamorphic crystalline rocks known as the Piedmont Plateau province. The Virginia Coastal Plain region is more than 100 miles wide, and includes approximately 9,500 square miles of territory, or about one-fourth the total area of the State.

Because of marked geologic differences in the two provinces, the larger streams, and many of the smaller ones, are characterized by falls or rapids where they cross the western margin of the Coastal Plain, and they always show a marked decrease in the velocity of their currents from this point eastward. For this reason, the name "fall-line" has been given to this boundary, the position of which is marked on the accompanying map, figure 1, page 8.

The Coastal Plain region, characterized by broad, level-topped stretches of country of low relief, gradually declines in slope from the Piedmont border to the shore-line. The deposits consist chiefly of unconsolidated beds of sand, gravel, clay and marl, which may be locally indurated by a cement either of iron oxide or carbonate of lime. These indurated ledges in the vicinity of Aquia Creek and, in places, southward along the western margin representing the oldest formation of the Coastal Plain series, have afforded sandstone suitable for building purposes. The beds strike in general from north to south, although some variation occurs, with a low but variable easterly dip. In age, the Coastal Plain beds range from Lower Cretaceous to Quaternary.

The Chesapeake Bay affords unparalleled transportation facilities, and its principal tributaries, the Potomac, Rappahannock, York, and James rivers, give access to vessels as far westward as the Piedmont border—the "fall-line."

The Piedmont Plateau Province.

The Piedmont Plateau province lies between the Coastal Plain and the Appalachian Mountains. It extends from the eastern slope of the Blue Ridge eastward to the western margin of the Coastal Plain, and it widens southward (map, figure 1, page 8). Its width increases from about 40 miles in the northern portion along the Potomac River to nearly 175 miles along the Virginia-Carolina boundary. The sediments of the Coastal Plain lie across the bevelled edges of the crystalline rocks of the Piedmont, presenting such marked stratigraphic and lithologic contrast that the geologic boundary between the two provinces is sharply defined. The transition on the west is less sudden and well marked.

The Piedmont province contains a greater variety of mineral resources than either of the other two provinces. In general, the surface of the Plateau has a gentle southeastward slope from an average altitude of 1,000 feet along the western margin to from 200 to 400 feet on the east, where the plateau rocks pass beneath the Coastal Plain sediments. The topography of the plateau is that of a more or less smooth, broadly rolling or undulating upland of moderate elevation, into which the streams have rather deeply sunk their channels.

The drainage of the region is to the southeast into the Atlantic waters, and the major streams which traverse the plateau are the Potomac, Rappahannock, James, and Roanoke rivers.

The rocks of the Piedmont region are the oldest in the State and, excepting the areas of Triassic rocks, they are all crystalline. They comprise both sedimentary and igneous masses usually greatly altered from metamorphism. The region is made up of a complex of schists, gneisses, and granites, with, in places, areas of slate, quartzite, and limestone. This complex is intersected by intrusions of basic eruptive rocks belonging to several different types. Over parts of the eastern and central portions of the region are areas of altered volcano-sedimentary rocks which extend southwestward into North Carolina.

The age of the rocks of the region, excepting the areas of Triassic rocks, ranges from probable Archean to early Paleozoic.

The Appalachian Mountains Province.

The Appalachian Mountains province embraces the western portion of the State. Its eastern boundary is the southeastern slope of the Blue Ridge and its western limits are artificially drawn in the western boundary of the State. This province, like the Piedmont Plateau and Coastal Plain, extends northeast and southwest far beyond the limits of Virginia.

The topography of the Appalachian province is varied and picturesque. Three subdivisions of the province are recognized which, named from east to west, are: (1) The Blue Ridge; (2) the Great Valley; and (3) the Alleghany Ridges. The limits of these subdivisions are indicated on the map, figure 1, page 8.

The Blue Ridge, which forms the eastern boundary of the Appalachian province, maintains an uneven and knobby crest entirely across the State, in a northeast-southwest direction, and has an average elevation of not less than 2,000 feet above tide-level. The Blue Ridge is composed largely of pre-Cambrian rocks, represented in part, at least, by various igneous types, but sandstones and shales of Cambrian age are exposed along the western slope. It is a natural dividing line between the Paleozoic sediments comprising sandstones, limestones, and shales on the west, and the pre-Paleozoic and other rocks on the east.

The two most westerly sub-provinces, the Valley and the Alleghany Ridges, bounded by the two principal ranges, the Blue Ridge and the Alleghany Front, on the southeast and northwest, respectively, are here treated together under the Greater Valley region. Considered broadly, the Greater Valley region is composed of narrow valleys and linear ridges arranged in more or less complex relations. It is composed throughout of Paleozoic sediments, which range in age from Cambrian to Carboniferous. The principal rock-types include limestone, shale, and sandstone.

The rocks composing the Greater Valley region have been folded and faulted and subsequently greatly eroded. As a result of the folding and subsequent erosion, the edges of the formation form linear ridges and valleys, developing the well-known Appalachian type of topography.

EFFECTS OF WEATHERING AND EROSION.

The surface rocks over all parts of Virginia show some effects from atmospheric action. Of the three major provinces of the State described above, the Coastal Plain, on account of its very recent geologic history, has suffered the least. The remaining two provinces, Piedmont Plateau and Appalachian Mountains, bear striking evidence over all their parts of profound decay and erosion, which have resulted in the removal of vast quantities of rock material. Just how much of their surface has been lowered, or what vertical thickness of material has been removed from these land areas and carried seaward, would probably be very difficult to say, but that it has been large can not be doubted. Because of its greater geologic age and the vast length of time it has been a land area, the Piedmont Plateau has probably suffered the removal of the greatest thickness of material.

Through this process of weathering a mantle of varying thickness of decayed rock material overlies the still fresh or sound rock, except where the erosive action has not been too excessive and the slopes too steep for its accumulation. This residual material is loose and porous or incoherent, consisting usually of clay, sand and gravel, and on the immediate surface forms soil. On depth it passes by imperceptible gradation into the hard and fresh unaltered rock. The thickness of residual material varies from a few inches to, in extreme cases, 100 feet. Over many parts of the State, exposures of the hard rock are rare, except along the stream courses where the mantle has been cut through by erosion.

This process of rock decay is of very great economic importance. Workable ore deposits have been formed by it from sparsely disseminated and non-workable mineral matter in the original rocks. This is best illustrated in the manganese deposits, in a part of the iron and zinc deposits, and in other ore deposits of the State.

DIVERSITY OF RESOURCES.

There is probably no state in the Union, of the same area as Virginia, that can show a greater diversity in geologic resources. This is confirmed by the actual exploitation thus far made, and it might be naturally inferred from the position which the State occupies with

reference to disturbed and undisturbed areas as described above. As indicated above and from an examination of the geologic map, the State stretches from the Atlantic coast westward nearly entirely across the Appalachian Mountain system. Within this area are found rocks ranging in age from pre-Cambrian to Recent, and representing all the principal divisions of geologic time. Equally as great a variety of rock-types, both sedimentary and igneous, of structure which characterizes both profoundly disturbed and undisturbed rock masses, and of topography, is shown.

The mineral products^a that have been mined and quarried in Virginia are discussed in this bulletin in the following order: Iron ores, manganese ores, gold and silver, copper, lead and zinc, tin, nickel and cobalt, coal and coke, clay and clay products, lime and cement, sand and gravel, sand-lime brick, stone (granite, marble, limestone, sandstone, slate, crushed stone, and furnace flux), abrasive materials (corundum, emery, and millstones), silica (quartz, chert, and diatomaceous earth), mica, feldspar, asbestos, talc and soapstone, barytes, gypsum, salt, mineral paints, marl, pyrite and pyrrhotite, arsenic, phosphate, graphite, rutile (titanium), mineral waters, and precious stones (quartz, garnet, allanite, kyanite, fluorite, feldspar, microlite, apatite, beryl, columbite, and helvite).

IRON ORES AND PIG IRON.

The present commercial deposits of iron ore in Virginia are confined to the Piedmont and Appalachian regions. The iron ores of the Piedmont region occur in metamorphic crystalline rocks of unknown age, probably pre-Cambrian in large part; those of the Appalachian region occur in sedimentary rocks of Paleozoic age, or the residual material derived from them.

The iron minerals used as ores of the metal in the State are, chemically, oxides, of which there are three important types, limonite (brown hematite), red hematite, and magnetite. Of these, the brown hematite has been and is the principal source of the metal, as indicated

^aA map of Virginia showing location of mines and quarries was published by the State Geological Survey in 1909 and partly distributed with Bull. No. I-A. Scale of map, 12 miles equals 1 inch.

in the table on page 21. The sulphides and carbonate, especially the former, occur in many places, but they do not form as yet an important source of the metal.

The iron ores of Virginia may be classified as follows:^a

PIEDMONT REGION:

1. Hematite. Specular hematite associated with magnetite in the James River valley.
2. Brown ore. Gossan ore forming a capping of pyrrhotite deposits in southwestern Virginia, and pyrite deposits in northern and central Virginia.
3. Magnetite. Associated with gneisses, schists, and crystalline limestones, in central and southwestern Virginia, and with basic intrusions in the Blue Ridge.

APPALACHIAN REGION:

1. Hematite.
 - (a) Siliceous specular hematite interbedded with lower Cambrian shale and quartzite in the Blue Ridge.
 - (b) Fossil (red) hematite interbedded with shale and sandstone of Clinton (Rockwood) formation in western and southwestern Virginia.
2. Brown ore.
 - (a) "Mountain" ores of the Blue Ridge and the New River district, associated with lower Cambrian quartzite and with residual material above it derived from the quartzite and from the overlying formations.
 - (b) "Valley" ores associated with residual material of the Shady limestone in the New River district. A few deposits of this nature occur with other limestones of the Shenandoah group along the Blue Ridge.
 - (c) Oriskany ores replacing the Lewistown limestone directly under the "Monterey" (Oriskany) sandstone in the western part of the Appalachian region.
3. Magnetite. Magnetite and hematite associated with limonite and iron carbonate in the upper part of the Shenandoah group locally in southwestern Virginia.
4. Iron carbonate. Iron carbonate occurring with limestone magnetite in the upper part of the Shenandoah group locally in southwestern Virginia, and as ironstone concretions in the Martinsburg and Romney shales.

In recent years, the iron ores of the Piedmont region have contributed only a very minor part of the total production of the ores in the State, though small quantities of magnetite and limonite (brown ore) are produced annually from this region.

Magnetite deposits, usually having the form of lenticular beds or elongated pods and interlaminated with gneisses, schists and, in places, limestones, are widely distributed through the Piedmont region.

^aHarder, E. C. Bulletin 380, U. S. Geological Survey, 1909, pp. 216-217. The sulphide types of iron ores are omitted from the scheme of classification, as they have not yet contributed to the production of metal in Virginia, but are utilized in acid making, and are treated under Pyrite and Pyrrhotite on pages 108-111.

They occur in Albemarle, Amherst, Appomattox, Buckingham, Fluvanna, Franklin, Grayson, Louisa, Nelson, Patrick Henry, and Pittsylvania counties. The James River valley area below Lynchburg was a principal iron-producing district in the State about a hundred years ago, and was exploited again about 1880. In recent years, the magnetite ore at Pittsville in Pittsylvania County has been the most extensively mined in the Piedmont region. The ore body has a thickness of 12 feet and occurs between crystalline limestone and mica schist. Magnetite has been mined near Rocky Mount, in Franklin County, and west of Goblintown Creek in Patrick County. The magnetite deposits vary in thickness up to 30 feet and more, and they show much irregularity (pinching and swelling) on both the strike and the dip. They vary greatly in composition, from bodies containing practically all iron ore to those made up largely of gangue minerals with but little ore. They include both non-titaniferous and titaniferous types.

Brown (gossan) ore, resulting from the oxidation of pyrite and pyrrhotite above groundwater level, has wide distribution through the Piedmont region. It occurs capping the pyrite bodies in metamorphic crystalline schists of unknown age, of Buckingham, Louisa, Prince William, Spotsylvania, and Stafford counties, and formed the basis for the first iron industry in Virginia; but it has not been mined in recent years. Similar ore occurs in Carroll, Floyd, Franklin, and Grayson counties, forming the capping of pyrrhotite deposits in metamorphic crystalline schists.

The "Great Gossan Lead" of Carroll-Floyd-Grayson counties is the most extensive one of the gossan leads. It is quite variable in width, ranging from a few feet up to more than 150 feet. The gossan consists of light brown or yellow limonite, which extends to a depth of from 10 to 60 feet, and has been mined in many places.

The brown iron ores of the Appalachian region, which include the "mountain," valley or limestone, and Oriskany ores, are commercially the most important ores in Virginia. The specular hematites of the Blue Ridge are second in importance, the Clinton fossil ores third, and the remaining types are of minor importance. These types of ores are briefly described below.

Specular hematite occurs in workable quantity along the Blue Ridge in Bedford, Botetourt, and Roanoke counties. It occurs interbedded with lower Cambrian quartzite and shale, and is believed to be sedimentary in origin. The ore bed is of variable thickness and has been worked at eight localities, as follows:^a "The Arcadia and Wood mines, about 4 miles southeast of Buchanan; the Ironville and Dewey mines, near Montvale; the Lemon, Grubb-Specular and Edith mines, about 3 miles northwest of Blue Ridge Springs; and the Griffin-Specular mine, about 5 miles south of Roanoke. Of these, the Arcadia, Wood, Dewey, and Edith mines are at present in operation." The ore is a very siliceous dark-red hematite, in which the iron content ranges from less than 35 per cent to 45 per cent, and the silica content from 30 to 40 per cent.^b

Fossil hematite, interbedded with shale and sandstone of the Clinton (Rockwood) formation of the Silurian system, occurs in workable quantity in Alleghany, Lee, and Wise counties. In Alleghany County, fossil ore has been mined on the southeast slope of Horse Mountain, 3 miles southeast of Lowmoor, and in the bluff northeast of Jackson River at Iron Gate. Only one workable bed of ore is known, which averages less than two feet in thickness. The ore mined is of the soft variety from which the calcium carbonate has been removed by surface waters, and it carries 46 to 57 per cent of metallic iron. According to Hayes,^c nearly 90,000 tons of fossil ore were shipped in 1907 from mines in the Alleghany County district.

In the Lee-Wise counties district of southwest Virginia, fossil hematite ore is mined south of Big Stone Gap on Wallen Ridge, and in Powell Valley, and southwest of Pennington Gap along Poor Valley ridge. The Yeary, Irondale, Keystone, and Oretton mines have been opened south of Big Stone Gap, and the Pennington, Lavine, Ben Hur, Truro, Noes Siding, Grabill, Boones Path, and Ewing mines are opened along Poor Valley ridge. In the southwest Virginia district there are three ore beds which have been mined, ranging in thickness

^aHarder, E. C. Bulletin 380, U. S. Geological Survey, 1909, p. 225.

^bIbid., pp. 227 and 228.

^cHayes, C. W. Bulletin 394, U. S. Geological Survey, 1909, p. 88.

from 6 inches to 2.5 feet. The ores mined are chiefly of the soft variety, and are of lower grade than those of the Alleghany County district.

The "mountain" brown ores, so called because of their occurrence along the flanks or at the base of a sandstone or quartzite ridge, extend along the west slope of the Blue Ridge from near Front Royal, in Warren County, to a point south of Roanoke, and along the east side of the New River-Cripple Creek district, in Pulaski County, and along and near to the Wythe-Carroll counties boundary. The ore deposits are associated with Cambrian quartzite or its residual material, usually the latter, show great variation in form and texture, and range in iron content from 35 to 50 per cent and in silica content from 10 to 30 per cent, with usually high manganese and phosphorus. They are of lower grade than the valley or limestone brown ores, and are regarded as concentrations by meteoric water, the iron having been derived largely if not entirely from the overlying shale and limestone formations.

The valley or limestone brown ores are distributed at intervals throughout the Valley region west of the Blue Ridge, in association with the residual clays derived from the limestone by processes of decay. The principal occurrence of these ores is in the New River-Cripple Creek district of Wythe and Pulaski counties, in residual clays derived from the Shady (lower member of the Shenandoah group) limestone. A large number of mines have been operated in this district.

In the northern and central Valley region the limestone brown ores are not so abundant, there being less than a dozen deposits that have been worked between Roanoke and the Maryland boundary. The ores of this region, called the Blue Ridge belt, occur in residual clays derived from the Natural Bridge limestone.

The ore is disseminated through the residual clay in varying concentrations ranging from large porous masses down to pellets the size of a pea. The proportion of clay to ore in the workable deposits varies considerably, usually from 5 to 1 to 25 to 1.^a The ores are usually richer than the "mountain" ores ranging in iron content from 40 to 55

^aHarder, E. C. Bulletin 380, U. S. Geological Survey, 1909, p. 244.

per cent, and in silica content from 5 to 20 per cent, with usually less than 1 per cent of manganese and enough phosphorus to be classed as a non-Bessemer ore.

The valley or limestone brown ores are residual deposits, the iron of which was originally disseminated through the rocks and, under favorable conditions, has been concentrated during the process of weathering and erosion.

The Oriskany brown ores are the most important of the iron ores mined at present in Virginia. The principal district of Oriskany ores includes the counties of Alleghany, Botetourt, and Craig, from which nearly all the ore mined of this type is produced. Minor deposits occur on Draper Mountain, in Pulaski and Wythe counties; on Peters Mountain, Giles County; in the Buffalo Gap area, Augusta County; in Massanutten Mountain, Shenandoah County; and on North Mountain, in Shenandoah and Frederick counties.^a

These ores are limited to a definite horizon, in the Lewistown (Helderbergian) limestone, immediately below the Monterey (Oriskany) sandstone. They represent replacements of the upper portion of the limestone. The ore was derived from the overlying Devonian black shales by meteoric waters. Where the shales were of sufficient thickness and the underlying Monterey sandstone sufficiently thin and fractured, the iron-bearing solutions penetrated into the underlying limestone and, under favorable conditions, replaced the calcium carbonate by iron oxide, forming the ore bodies.

The ore deposits are continuous for considerable distances along the strike with great variations in thickness of the ore bodies shown, ranging up to 75 feet with a probable average of 15 to 25 feet. The ore, usually fairly solid but frequently porous with the cavities containing clay, ranges between 35 and 50 per cent of metallic iron. They are usually high in silica and manganese, resembling in this particular the "mountain" ores.

The principal Oriskany brown ore mines^b in the State are Liberty and Van Buren Furnace mines, in Shenandoah County; the Buffalo Gap and Ferrol mines, in Augusta County; the Victoria and Longdale mines, north of Longdale, Alleghany County; the Dolly Ann,

^aHarder, E. C. *Ibid.*, p. 246.

^bOp. cit., p. 248.

Iron Mountain, and Stack mines, near Covington, Alleghany County; the Lowmoor and Rich Patch mines, near Lowmoor, Alleghany County; the Jordan mines, on Potts Creek, Alleghany County; the Callie, Wilton and Circle mines, near Glen Wilton, Botetourt County; the Oriskany and Fenwick mines, in Botetourt and Craig counties, near Oriskany; the Gala mines, near Dagger Spring, Botetourt County; the Clayton and Peak Knob mines, near Pulaski, Pulaski County; and the Locust Hill mine, near Max Meadows, Wythe County.

The remaining types of Appalachian iron ores in Virginia, including the limestone magnetite and iron carbonate ores, are of minor importance. The principal deposits of the limestone magnetite ores, so far known, occur near Big Sandy Junction, in Giles County, and near Abingdon, in Washington County, with smaller deposits elsewhere in southwest Virginia. Iron carbonate is reported in minable quantity from only one locality, namely, near Abingdon, in Washington County, in association with limestone magnetite ore.

The iron ores of the State are under investigation by the Virginia Geological Survey, after the completion of which a detailed report will be published.

The iron ore mining industry in Virginia showed a decided increase in 1909, the figures of production being 837,847 long tons, valued at \$1,693,188, as against 692,223 long tons, valued at \$1,465,691 in 1908. This was an increase over the 1908 production, of 145,624 long tons or 21.03 per cent in quantity, and \$227,497 or 15.52 per cent in value. The average price per tone of ore in 1909 was \$2.02.

The production of iron ores in Virginia during 1910 amounted to 903,377 long tons, valued at \$1,845,144. These figures represent an increase over the production for 1909, of 65,530 long tons or 7.82 per cent in quantity, and \$151,956 or 8.97 per cent in value. The average price per ton of the iron ore mined in Virginia during 1910 was \$2.04. The 1910 production of iron ores in the State represented the output of forty-nine mines distributed among fourteen producers operating in the same number of counties (14). The counties producing iron ore

in the State during 1910 were as follows: Alleghany, Augusta, Bedford, Botetourt, Carroll, Craig, Lee, Pittsylvania, Pulaski, Roanoke, Rockbridge, Smyth, Washington, and Wythe.

There is given in the table below the total production of iron ore in Virginia by varieties, from 1900 to 1910, inclusive. It will be observed that brown hematite is vastly the most important, producing at present 90.89+ per cent of the total. The next in order of importance is red hematite, which contributed, in 1910, a little over 9 per cent of the total production, while magnetite for the same year amounted to less than a half of one per cent.

Production of Iron Ore in Virginia, by Varieties, 1900-1910, in long tons.

Year	Brown hematite	Red hematite	Magnetite	Total quantity	Total value
1900 ^a	918,157	3,664 .....	.....	921,821	\$1,489,318
1901 ^a	910,214	13,156	2,024	925,394	1,466,423
1902 ^a	953,128	31,677	3,153	987,958	1,667,456
1903 ^a	764,948	31,609	4,604	801,161	1,432,624
1904 ^a	528,853	17,952	3,448	550,253	951,478
1905	704,470	35,357	518	740,345	1,256,428
1906	735,204	92,257	620	828,081	1,579,817
1907	696,518	89,867	471	786,856	1,538,920
1908	620,910	64,323	990	692,223	1,465,691
1909	762,937	72,955	1,955	837,847	1,693,188
1910	821,131	81,647	599	903,377	1,845,144

^aIncludes West Virginia, but practically the total production was from Virginia.

A good idea of the distribution of the different varieties of iron ore produced in Virginia in 1910 may be gained from the table below, in which the total production is classified by varieties and counties. Brown hematite, which constitutes at present the chief ore, comes mostly from the Appalachian counties west of the Blue Ridge, with only a minor production from the counties in the crystalline area. The same is true for the production of hematite, which now stands next in importance to brown hematite. Deposits of magnetite are widely distributed through the crystalline area, which form important reserves of iron ore, but the production of magnetite in the State has been very small and of minor importance.

*Production of Iron Ore in Virginia, by Counties and Varieties, 1910,
in long tons.*

County	Brown hematite Long tons	Value	Red hematite Long tons	Value
Alleghany	234,772	\$ 582,068	(a)	(a)
Augusta				
Bedford	147,298	272,768	(a)	(a)
Carroll				
Craig				
Botetourt	168,148	398,928		
Lee			(a)	(a)
Pittsylvania				
Pulaski	127,185	202,099		
Roanoke				
Smyth				
Rockbridge	14,001	31,216		
Washington	130,826 ^b	215,939		
Wythe				
Total.....	821,730	\$1,703,018	81,647	\$ 142,126

^aIncluded under total in order to avoid disclosing individual production.

^bIncludes 599 tons of magnetite.

The average price per long ton of the different varieties of iron ore produced in Virginia during 1910 follows: Brown hematite \$2.07, red hematite \$1.74, and magnetite \$1.50. These prices represent the value of the ore at the mouth of the mine, and are taken directly from the replies of the producers.

The production of pig iron in Virginia during 1909 amounted to 391,134 long tons, valued at \$5,550,000, as compared with 320,458 long tons, valued at \$4,578,000 in 1908, an increase in quantity of 70,676 long tons or 22.05 per cent, and in value of \$972,000 or 21.21 per cent. The 1910 production of pig iron in Virginia amounted to 444,976 long tons, valued at \$6,150,000, an increase over the production of the preceding year of 53,842 long tons in quantity, and \$600,000 in value.

There is given in the table below the production of pig iron in Virginia for the years 1905 to 1910, inclusive.

Production of Pig Iron in Virginia, by years, 1905-1910.

Year	Quantity Long tons	Value	Value per ton
1905	510,210	\$7,540,000a	\$14.78
1906	483,525	8,591,000a	17.77
1907	478,771	8,963,000	18.72
1908	320,458b	4,578,000	14.29
1909	391,134b	5,550,000	14.19
1910	444,976b	6,150,000	13.82

aEstimated.

bBirkinbine, J. Personal communication.

LIST OF IRON ORE OPERATORS

OPERATOR	OFFICE	MINE
Barr Ore & Iron Corporation.....	Pittsville	Pittsville.
Bentonville Mining Co.....	Philadelphia, Pa	Bentonville
Black, H. A and J. L.....	Staunton	Stuarts Draft
Bland Iron & Coal Co.....	Wytheville	Bland County
Boone's Path Iron Co.....	Baltimore, Md	Rose Hill Station
Botetourt Mineral & Mining Co.....	Fincastle	
Buena Vista Iron Co., Inc.....	Johnstown, Pa	Buena Vista
Catawba Mining & Manufacturing Co.....	Roanoke	
Coots, Graham	Basic City	Staunton
Crescent Iron Ore Co.....	New York, N. Y.....	Stanley and Stanleyton
Crowder, Delaney & Miller.....	Covington	Clifton Forge
Elliotts Knob Coal & Iron Co.....	Buffalo Gap	
Eureka Manganese Co.....	Stanleyton	Stanleyton
Franklin, G. H.....	Brights	Brights
Goshen Iron Co., Lessee, Chapman Iron, Coal & Coke Co.....	Goshen	Clifton Forge
Graham Heirs, Part Owners of Virginia Iron, Coal & Coke Co.....	Graham Forge	
Halser, Ira F.....	Troutville	Troutville
Hatcher & Sheaffer.....	Pulaski	Peak Knob and Pulaski
Horneck Construction Co.....	Cumber'l Gap, Tenn..	Ben Hur and Jonesville
Indian Camp Mining Co.....	Max Meadows	Ivanhoe
Ivanhoe Furnace Co.....	Pittsburg, Pa.....	Abingdon Austinville Fries Ivanhoe
Keystone Coal & Iron Co.....	Philadelphia, Pa	Oreton
Laing, J. B.....	Lewisburg, W. Va., or Newcastle.	
Little, J. F.....	Newcastle	Waitsville
Lobdell Car Wheel Co.....	Wilmington, Del	White Rock Furnace
Longdale Iron Co.....	Longdale	Australia
Lowmoor Iron Co. of Virginia.....	Lowmoor	Backbone, Covington, Lowmoor, and New castle
McLean, James G.....	Pittsburg, Pa.....	Raphine
Manganese Iron & Coal Co.....	Newcastle	Newcastle
Oriskany Ore & Iron Corporation, Lessees Alleghany Ore & Iron Co.....	Iron Gate	Lignite and Vesuvius

OPERATOR	OFFICE	MINE
Persinger, J. W.....	Buena Vista	Rich Patch
Pittsville Mining Co.....	Pittsville	Pittsville
Poplar Camp Mining Co.....	Max Meadows	Ivanhoe and Max Meadows
Princess Furnace Co.....	Glen Wilton	Glen Wilton
Pulaski Iron Co.....	Pulaski	Allisonia, Buchanan, Cripple Creek, Foster Falls, and Pulaski
Sanders & St. Clair.....	Troutville	Troutville
Scherr, A. C. and others.....	Charleston, W. Va.....	Grottoes
Seibel, H. J.....	Happy Creek	Happy Creek
Spoor, W. M.....	Abingdon	Adwolf
Thrush, H. H.....	Front Royal	Limeton
Union Iron & Steel Co., L. O. Pettit, Receiver	Big Stone Gap.....	Ewing
Utah-Virginia Mining Corporation.....	Salt Lake City, Utah.....	Troutville
Vesuvius Mining Co.....	Baltimore, Md	Greenville
Virginia Clay & Material Co.....	Farmville	Farmville
Virginia Iron, Coal & Coke Co.....	Roanoke	Allisonia Baker Mines Barren Springs Blue Ridge Springs Clark Summit Cotopaxi Cripple Creek Foster Falls Graham Interior Max Meadows Montvale Ogden Reed Island Roanoke Speedwell
Virginia Iron & Lumber Co.....	Philadelphia, Pa	
Virginia Ore & Iron Co.....	Baltimore, Md	Berryville
Waits, Sterling	Max Meadows	Austinville
West End Furnace Co.....	Roanoke	Allisonia
Williams & Son, John T.....	Bristol, Va.-Tenn	Bonsacks
Willis & Nutson	Hamakertown	
Wissler Mining Co.....	LaFollette, Tenn	Ivanhoe
Zinns Iron Mining Co.....	Washington, Pa.....	Vesuvius

MANGANESE ORES.

Virginia has more known deposits of manganese, they extend over a larger territory, a larger number of localities have been worked, and more manganese has been produced than in any other state in the Union. Manganese ores occur in each of the three major geologic provinces of the State, namely, the Coastal Plain or Tidewater belt, the Piedmont province or crystalline area, and the Appalachian Mountains province or Paleozoic area. Of these the Mountain (Valley) province has yielded the principal production, with extensive operations and a large total production from the Piedmont province. Only

a slight production has come from the eastern or Coastal Plain province.

Manganese occurs natively in a variety of mineral combinations but only the oxides of the metal are of commercial importance in Virginia. Of these, pyrolusite and psilomelane greatly predominate with, in places, much of the earthy oxide, wad. These different oxides often occur admixed in varying proportions. The ore is frequently partially or entirely crystalline, of a dark steel-blue color, and the nodular (kidney) type, which usually prevails, often displays the complete or partially layered structure of concretionary masses.

The manganese ores are usually found imbedded in the residual clays which overlie the rocks, from which the clays have been derived by the usual processes of decay. The underlying rock yielding the ore-bearing clays may be of sedimentary or igneous origin, and may be the usual consolidated sediments, or a metamorphic crystalline type.

The ore is distributed through the clays in an irregular manner in the form of pockets or lenticular masses, rarely as distinct beds; as veinlets and stringers cutting the clays in all directions; as single nodules and masses, ranging in weight up to 500 pounds, assembled in the clays; as small disseminated grains scattered through the clays; as breccia ore in large masses; and as probable replacement and cavity fillings in sandstone or sandy clay. In places, both in the Piedmont and Valley regions, the ore distribution conforms in a general way to the bedding of the inclosing clays; frequently, however, this is obscured and the ore bodies indiscriminately cut the clays in all directions.

In the Piedmont region where the residual clays have been derived from the decay of crystalline schists, and the original schistosity of the rocks preserved in the clays, the ore frequently conforms with the foliation and is disposed in thin stringers and sheets much after the manner of interleaving. The pockets show much variation in size and number, ranging from small nests to bodies yielding many tons of ore. They are rarely composed of solid ore free from clay, but the ore forms thickly-studded nodules in the clays. The pockets may be closely spaced or they may occur at wide intervals, usually not connected,

although at times stringers or irregular nodules may lead from one pocket to another.

The principal productive manganese deposits in Virginia are (1) those of the Piedmont region, occurring chiefly in Campbell and Nelson counties, northeast and south of Lynchburg; and (2) those of the Valley region occurring along the west slope of the Blue Ridge. Numerous mines have been worked in the Piedmont region.

In the Valley region the principal manganiferous ore belt lies along the west slope of the Blue Ridge. Workable deposits of manganese ores have been found in each county bordering on the western slope of the Blue Ridge. The Blue Ridge iron ore mines occur along this belt, many of which contain some manganese in the form of manganiferous iron ore, and similarly many of the manganese deposits contain some iron. The manganese ores are usually found embedded in residual clays derived from Cambrian ferriferous shales, which overlie the Cambrian quartzite. In other places over the Valley region, manganese ores occur similarly embedded in residual clays derived from limestone of Cambro-Ordovician age. The famous Crimora mine in Augusta County has produced more manganese ore than all other mines in the United States combined.

Virginia has always been the principal producer of manganese ores in the United States. The figures of production in 1909 were 1,334^a long tons, valued at \$14,275, as compared with 6,144 long tons, valued at \$62,776 in 1908. This represents a loss of 4,810 long tons, or 78.3 per cent, in quantity, and \$48,501, or 77.25 per cent, in value. There were 2 producers of manganese ores in 1909, operating in 2 counties. The production for 1910 was as follows: 2,059^a long tons, valued at \$18,509. These figures represent an increase, over the 1909 production, of 725 long tons in quantity, and \$4,234 in value. There were four producers of manganese ore in 1910, and one of manganiferous ore. The production came from the following four counties: Augusta, Campbell, Rockingham, and Warren. In addition to the figures given above, 2,085 long tons of manganese ore were reported as stock on hand at the close of 1910.

There are given in the table below the figures of production and value of manganese ores in Virginia from 1903-1910, inclusive.

^aIncludes small production of manganiferous ore.

Production and Value of Manganese Ores in Virginia, 1903-1910.

Year	Quantity Long tons	Value	Average value per ton
1903	1,801	\$ 19,611	\$10.89
1904	3,054	28,406	9.30
1905	3,947 ^a	35,209	8.92
1906	6,028	77,522	12.86
1907	4,604	56,469	12.27
1908	6,144 ^b	62,776	10.22
1909	1,334 ^c	14,725	10.70
1910	2,059 ^c	18,509	8.98

^aIn addition, 453 tons of tailings, valued at \$406, were shipped.^bIn addition, 274 tons of manganeseiferous iron ore were sold.^cIncludes small production of manganeseiferous ore.

LIST OF MANGANESE ORE OPERATORS

OPERATOR	OFFICE	MINE
Atkins, Geo. M.	Attoway	Attoway
Bear Pond Lumber, Coal & Oil Co.	Gettysburg, Pa.	Capon Roads
Benham, Wm. J.	Philadelphia, Pa.	Woodstock
Binswanger & Co., H. P.	New York, N. Y.	Woodstock
Cameron, Donald	Baltimore, Md.	Woodstock
Carnahan, J. W.	Wytheville	Rural Retreat
Cole, Hugh F.	Chilhowie	Chilhowie
Cook & Son Mining Co., D. S.	Wrightsville, Pa.	Gala
Cox, Charles W., Assignee, Henry W. Poor & Co.	New York, N. Y.	Crimora
Cuthbert, W. R.	Lynchburg	Evington
Dry Run Mining & Development Co.	Norfolk	Compton
Eagle Cliff Mining Co.	Atkins, R. F. D. No. 2.	Ivanhoe
Etna Iron & Manganese Co.	Lynchburg	Mt. Athos
Eureka Manganese Co.	Stanleyton	Stanleyton
Evington Manganese Co.	Evington	Evington
Forney Mining Co.	Roanoke	
Harmon, C. H., Prop., Magie, H. M., Operator	Waynesboro	Crimora
Lackey, L. B.	Happy Creek	Happy Creek
Lang, S. J.	Harrisonburg	Middle River District
Loeb, Simon F.	McKeepsport, Pa.	Otter River
McCormick, F. Olney.	Philadelphia, Pa.	Zepp
McCune, Samuel	Meadow Mills	Cedar Creek
McGovern, Wm., B. F. Buchanan, Lessee.	Bristol, Tenn.	Sugar Grove
Main, T. F.	Wytheville	Wytheville
Manganese Corporation of Virginia.	New York, N. Y.	Vesuvius
Marchant, E. W.	Attoway	Marion
Metal Manufacturing Co.	Elkton	Elkton
Metallic Alloys Co.	New York, N. Y.	Lyndhurst
Midvale Mining Co., Inc., F. W. Schultz	Baltimore, Md.	Midvale
National Manganese Corporation.	Washington, D. C.	Lyndhurst
Piedmont Manganese Co.	Lynchburg	Mt. Athos
Pittsville Mining Co., E. R. Hutter, Proprietor	Pittsville	Pittsville
Poor & Co., Henry W.	New York, N. Y.	Crimora
Rockingham Mineral Co., Inc.	Elkton and Pittsburg, Pa.	Elkton
Seibel, H. J., Jr., Prop., and Lackey, L. G., Philadelphia, Pa., and Supt.	Happy Creek	Happy Creek
Southern Manganese Mining Co.	Harrisonburg	Front Royal
Staley's Creek Manganese & Iron Co.	Marion	Currin Valley
Steele Ore Co., care Royal Baking Powder Co.	New York, N. Y.	Stuarts Draft
Stoner, K. B.	Fincastle	Troutville
Tate, James, D.	Chilhowie	Marion
Weightman, Wm. (Hampton L. Carson, Attny. for Anne M. Walker)	Philadelphia, Pa.	Mt. Athos

GOLD AND SILVER.

The Virginia Mining Company of New York, operating between the years 1831 and 1834 the Grasty tract of land in Orange County, was the first gold mining company incorporated in Virginia. In 1836, there was considerable activity in gold mining in the State, and the production was reasonably steady from the rediscovery in 1831 to 1850, the annual value being given between \$50,000 and \$100,000. Increased activity in gold mining in the State was manifested in the early fifties, but the Civil War almost completely stopped mining operations in Virginia and in the South generally. Considerable activity was again manifested in the Virginia gold fields after the close of the Civil War, and milling and reduction plants were erected at various points. Many of these attempts met with only small success and in most cases were abandoned, not because of the lack of ore, but because largely of bad management and inexperienced mining, together with a change from free milling to pyrite ores.

The principal gold-bearing areas are arranged in a belt which begins in Montgomery County, Maryland, and extends across Virginia in a southwestward direction to the North Carolina line. The belt varies in width from 15 to 25 miles, and is 200 miles long, with its best developed portion in Fauquier, Stafford, Culpeper, Orange, Spotsylvania, Louisa, Fluvanna, Goochland, and Buckingham counties. Gold is also found in Appomattox, Prince Edward, Charlotte, Halifax, and Pittsylvania counties, which mark the southwest extension of the principal belt. Excepting Halifax, which has been a producer for several years, no developments have been made in the last-named counties.

A smaller belt occurs on the west side of the Blue Ridge in Montgomery, Floyd, and Grayson counties, but is undeveloped and has proved of little economic importance.

Many of the mines in the principal belt have produced large quantities of gold, as shown in the United States mint returns, and have been rather extensively worked. Preparations are in progress for the resumption of mining at a number of the mines in the principal belt. During 1910 considerable interest was manifested at many

places within the belt in exploiting old and new properties. The principal gold belt is crossed by innumerable streams bordered by placers, many of which have been worked over several times.

The principal rocks of the gold belt are micaceous schists and gneisses, often garnetiferous and chloritic, and in places hornblendic. They include both altered sediments and igneous masses. The prevailing strike is N. 20° E., and the dip is toward the east and southeast at varying angles, frequently steep, and in many cases nearly vertical. Granite masses and basic igneous rocks occur in the region, sometimes sheared from dynamic causes.

The gold-bearing veins are chiefly quartz, which vary in texture from large crystalline masses to very fine saccharoidal grains. In structure, they vary from massive to thin platy or schistose bodies, both usually penetrated by closely spaced irregular fractures. The principal metallic content is auriferous pyrite, which at times is copper-bearing and contains more or less admixed chalcopyrite. Within the weathered zone, extending from the surface down to local water-level and of varying depth, the quartz is more or less porous and discolored or stained with iron oxide from the oxidation of the sulphide minerals, and the liberation of free or elementary gold. Below the local water-level the veins are fresh, the sulphides are unaltered, and elementary gold is less frequent in occurrence. The early operations were confined largely to the oxidized portions of the veins which yielded a free-milling ore that was easy of treatment. Since then, operations chiefly include the mining of sulphurets or the sulphide bodies, which require a different metallurgical treatment of the ores in order to extract and recover the gold.

The gold-bearing veins conform in the main to the structure, strike and dip of the inclosing rocks, a fact which has caused various explanations to be advanced for their origin by different observers. Although the veins conform in the main to the dip and strike of the inclosing rocks, the correspondence is far from being exact, for they frequently cut the schists at small angles both in dip and strike.

Excepting quartz and pyrite, the gangue minerals in the gold veins of Virginia comprise the following species: Chalcopyrite, native copper, galena, mispickel (arsenopyrite), pyromorphite, tetrahedrite,

tourmaline, vanadinite, sphalerite, pyrrhotite, and siderite. So far as the gangue minerals are concerned, the Virginia gold ores are entirely typical in character. The ores are quartzose deposits in which pyrite is usually present, chalcopyrite common, and mispickel and sphalerite are not rare.

In 1904, the production of gold and silver in Virginia was contributed to by eleven counties. From the United States mint returns for 1905, the gold production in Virginia increased in value, over 1904, \$1,182; and silver decreased \$3,779. In 1905, seven mines were reported producing, three of which were placer mines. According to Lindgren, the four deep mines yielded an estimated tonnage of 800, with an average value of \$5.35 per ton in gold and silver. The production in 1906 showed an increase over that of 1905 of \$9,850 in gold and \$61 in silver. There were 9,565 short tones of siliceous ores raised which yielded an average extraction of \$4.17 per ton. There was no reported production for the year from placer mines. In 1907, the total production of gold was valued at \$8,288 and of silver \$146, a decrease from that of 1906. According to McCaskey, seven mines reported a production, six of which were deep mines, yielding 26,822 short tons of ore. Of this, 1,128 short tons were siliceous ores which yielded an average extraction of \$7.33 per ton in gold and silver; 25,044 short tons were siliceous and cupriferous sulphide ores, giving an extraction of \$0.002 per ton in the precious metals; and the remainder were lead ores which yielded no gold or silver.

Four placers and four deep mines reported a production in 1908. According to McCaskey, the deep mines reported 12,877 tons of ore, 230 tons of which were siliceous gold ores, with an average value in precious metals of \$7.135 per ton, and 1,896 tons were copper ores yielding \$0.05 in precious metals and 12.4 pounds of copper per ton. Eight hundred (800) tons of lead ores yielded gold and silver valued at \$0.28 and 95.2 pounds of lead per ton.

Virginia produced, in 1908, 118.57 fine ounces of gold valued at \$2,451, and 236 fine ounces of silver valued at \$125. This shows a decrease from the production of 1907 in gold of 283.43 fine ounces in quantity, and of \$5,849 in value, and a decrease in silver of \$21 in value, but an increase of 15 fine ounces in quantity. In 1909, the

total production of gold was 181.41 fine ounces valued at \$3,750, and of silver 4,825 fine ounces valued at \$2,509, an increase in value over that of 1908 of \$1,299 of gold and \$2,384 of silver. Eight mines contributed to the production, five of which were placers and three deep mines. According to McCaskey, the deep mines yielded 14,075 tons of ore, 250 tons of which were siliceous gold ore of an average value of \$2.09 per ton, and 13,825 tons were copper ores and pyrite cinder yielding 35 cents in precious metals and 16.2 pounds of copper per ton.

In 1910, the production of gold and silver in Virginia showed a marked decrease over that of 1909. The total production of gold was 42.96 fine ounces valued at \$888, and of silver 128 fine ounces valued at \$69.

There is given in the table below, compiled from the production reports of the United States Mint and Mineral Resources of the United States, the production of gold and silver in Virginia by years.

Production of Gold and Silver in Virginia by years.

Year	Value	Year	Value
1799-1879.....	\$3,091,700	1895.....	\$ 6,325
1880.....	11,500	1896.....	4,466
1881.....	10,000	1897.....	Not given.
1882.....	15,000	1898.....	4,500
1883.....	7,000	1899.....	7,160
1884.....	2,500	1900.....	3,200
1885.....	3,500	1901.....	5,720
1886.....	4,000	1902.....	6,227
1887.....	14,600	1903.....	18,630
1888.....	7,500	1904.....	7,686
1889.....	4,113	1905.....	5,122
1890.....	6,496	1906.....	15,000
1891.....	6,699	1907.....	8,434
1892.....	5,002	1908.....	2,576
1893.....	6,190	1909.....	6,259
1894.....	7,643	1910.....	957

In the subjoined table are given the quantity and value of gold and silver produced in Virginia for the years 1906, 1907, 1908, 1909, and 1910.

Production of Gold and Silver in Virginia by years, 1906-1910.

Year	Gold		Silver	
	Quantity in fine ozs.	Value	Quantity in fine ozs.	Value
1906.....	717.50	\$14,832	250	\$168
1907.....	400.93	8,288	221	146
1908.....	118.57	2,451	236	125
1909.....	181.41	3,750	4,825	2,509
1910.....	42.96	888	128	69

COPPER.

Copper ores are found in many counties of the State and in a variety of occurrences. They are confined to the crystalline rocks of the Piedmont Plateau and the Blue Ridge Mountains, and to the Triassic red beds, which form numerous small areas in the Piedmont province:

The known geographic areas of these ores in the State are:

I. THE PIEDMONT REGION:

- (1) The Virgilina district, which includes Halifax and Charlotte counties in Virginia, and Person and Granville counties in North Carolina.
- (2) The deposits on or near Southwest Mountain in Albemarle County, and those near New Canton, Arvonia, and Dillwyn, in Buckingham County.
- (3) The pyrite bodies in Louisa, Stafford, and Prince William counties, mined principally for their sulphur content, but carry at times sufficient copper to warrant saving.

II. THE NORTHERN BLUE RIDGE REGION:

Includes those deposits from near Front Royal southward, embracing parts of Warren, Fauquier, Rappahannock, Madison, Page, and Greene counties.

III. THE SOUTHWEST VIRGINIA REGION:

Includes the "Gossan Leads" of the Floyd-Carroll-Grayson counties plateau.

IV. THE TRIASSIC AREAS:

Includes deposits chiefly in Loudoun, Culpeper, and Orange counties.

Geologically, the copper ores are confined to the crystalline rocks, either the schists or gneisses or the massive igneous rocks of the Piedmont and Blue Ridge provinces, and to the red shale-sandstone series

of the Triassic areas. In the Virgilina district, the ores occur in quartz-fissure veins which intersect or lie in an altered andesite and associated tuffs of probable pre-Cambrian age. The ores of the northern Blue Ridge region are segregated in and disseminated through basaltic flows of pre-Cambrian age, rocks designated by Keith as Catoctin schist. The "Great Gossan Lead" of the Floyd-Carroll-Grayson counties plateau, in southwest Virginia, is a mineralized faulted zone in schists of doubtful age, probably pre-Cambrian in part. The rocks are in part altered sediments and in part altered igneous masses of basic and acid types, principally the former.

The Virginia copper deposits may be grouped into five types:

- (1) Pyrite masses in schistose rocks worked chiefly for their sulphur content, but containing enough copper in places to be saved. The well-known and extensively worked pyrite bodies near Mineral, in Louisa County, and near Dumfries, in Prince William County, are the best representatives of this type.
- (2) Pyrrhotite veins containing chalcopyrite and some pyrite in schistose rocks referred to usually as the Ducktown, Tennessee, type, the most productive copper district in the South. The best representative of this type in Virginia is the "Great Gossan Lead" in Carroll County.
- (3) The Virgilina type in Virginia and North Carolina which represents quartz-fissure veins carrying chalcocite (copper glance) and bornite (horseflesh ore), with little or no pyrite and chalcopyrite, in volcanic rocks of intermediate character and their associated tuffs.
- (4) The northern Blue Ridge or Catoctin type, the ores of which are chiefly native copper and cuprite with small amounts of the carbonates, azurite and malachite, and very rarely copper sulphides associated with epidote and quartz in a basic volcanic rock, and as grains disseminated through the rock.
- (5) The Triassic type, carbonate, representing sparsely disseminated copper ores, chiefly sulphide, and phosphate of copper, in sandstones and shales of Triassic age.

In addition to these five types, copper in the form of the mineral chalcopyrite is a frequent associate with gold in the gold-bearing quartz-pyrite veins in the principal gold belt of the Piedmont province. Copper has not been observed, however, at any locality within the State in this mode of occurrence to be regarded as of commercial value.

Mining operations for copper in the State have been confined principally to three districts; namely, the Virgilina district, the northern Blue Ridge district, and the "Great Gossan Lead" district. Isolated deposits, which do not properly fall within either of these three districts, have been exploited in a number of localities, confined almost exclusively to the Piedmont counties.

The Virgilina copper district is, commercially, the most important district in Virginia, and the systematic study and detailed mapping on a large scale of the district has been completed by the State Survey, and the report is nearly ready for the press. It is located 47 miles east of Danville on the Atlantic and Danville division of the Southern Railway, and includes a part of Halifax, Charlotte, and Mecklenburg counties.

The principal developments in the district, which include a large number of mines, are confined to an approximate north-south distance of eighteen miles, and an average width of from two to three miles. The present productive portion of the district has about equal extension in the two states, Virginia and North Carolina. The country rock is schist, derived principally from intermediate and acid volcanic rocks and their associated tuffs. The schistosity of the rock strikes N. 10° to 20° E. and dips eastward from 70° to 80° . The quartz veins, of which there are many, are usually more or less parallel, and strike N. 5° to 10° E., with considerable variations from this direction in places. Mining developments show that copper occurs in most of the veins in greater or less quantity. The veins are lenticular bodies of quartz which, in some cases, show very uniform continuous outcroppings at the surface. The workable ores comprise chalcocite or glance (copper sulphide) and bornite (copper-iron sulphide) in a siliceous gangue. Small masses of calcite and feldspar are occasionally noted as gangue minerals. Cuprite (copper oxide), malachite and azurite (green and blue carbonates of copper) occur as alterations of the original sulphides. Some native copper is noted in places. Chalcopyrite and pyrite are almost entirely absent. The worked ores are free from arsenic and antimony, but carry values in both silver and gold, particularly the former.

The "Great Gossan Lead" of Floyd, Carroll, and Grayson counties is a vein traceable for some eighteen miles. It is composed chiefly of pyrrhotite with admixed quartz and schist, and carries streaks and patches of chalcopyrite and pyrite. The vein fills a fault fracture in crystalline schists, varies in width from a few feet to one hundred feet, shows a somewhat variable but average dip of about 45° , and has in general an approximate northeast trend. The region was actively

prospected in the early fifties, and the rich secondary copper ores found beneath the gossan were boxed and shipped to Baltimore. During 1854-5, there were eight producing mines on the "Gossan Lead"; the aggregate amount of ore shipped for the six months from January, 1855, to July, 1855, being 1,454,363 pounds. The ore averaged about 25 per cent copper. The copper content of the sulphide masses is too low (averaging less than 1 per cent metallic copper) to work for copper alone, but the vein is mined on Chestnut Ridge and the ore treated at Pulaski for sulphur, so that the residue is available for copper.

The northern Blue Ridge region, which extends from near Front Royal southward, embracing parts of six counties, has been extensively prospected, and many mines have been developed, but as yet with little production of the metal. The ores of the Blue Ridge region consist chiefly of cuprite and native copper, small amounts of green and blue carbonates, and less of the sulphides, bornite and chalcopyrite. The native copper often occurs as nucleal masses surrounded by cuprite. Bornite is in excess of chalcopyrite. The ore occurs along crevices and joints in small, irregular shaped lenses of quartz, and as disseminated grains through the more epidotized portions of the basalt. It occurs mostly where the rocks are fractured and epidotized. When ore-bearing, the rocks are yellowish green in color, due largely to the formation of epidote and, in part, of chlorite.

During the early part of the last century, attempts were made to mine the sparsely disseminated copper ores in the red sandstones and shales of Triassic age over parts of Loudoun, Culpeper, and Orange counties. While considerable work was done, the ores appear to be too generally diffused in the rocks to be of commercial value. No veins have been found and no well-defined horizons are known, the ores occurring for the most part as films or thin coatings of malachite on the joint surfaces, and as disseminated grains of the sulphide and phosphate of copper through the rocks. Rich specimens of copper glance and copper phosphate are sometimes obtained, but they are by no means abundant.

The production of copper in Virginia during 1909 was 224,162 pounds, valued at \$29,141, as compared with 24,775 pounds in 1908,

valued at \$3,270, an increase of 199,387 pounds in quantity and \$25,871 in value. The production in 1910 showed a marked decrease over that of 1909, amounting in total to 5,402 pounds in quantity, valued at \$686.

LEAD AND ZINC.

Lead mining in Virginia dates back more than 150 years, and the old lead mines at Austinville on New River, in Wythe County, were the first to be worked. For many years after the Virginia mines were operated, mining was confined exclusively to the lead ores. Zinc ores were first discovered at Bertha near Austinville, in Wythe County, during the year 1876. Mining of zinc ores in Virginia dates from the opening of the mine at Bertha in 1879, when a small shipment of ore was made to Providence, Rhode Island. The metal obtained from these ores proved to be of such rare purity that attention was directed at once to them, and a smelting plant was built at Pulaski, which was later remodeled and enlarged, and is owned and operated at present by the Bertha Mineral Company. The "Bertha" spelter is of exceptional purity, and has a world-wide reputation.

Excepting the single deposit in the extreme southwestern part of Albemarle County, the known deposits of lead and zinc in Virginia are limited to the Valley province west of the Blue Ridge. All mining and prospecting for lead and zinc ores in this province have been confined to the western half, extending from and including Roanoke County on the east to and including Scott County on the southwest. Ores of lead and zinc are known to occur either sparingly or in quantity in the following counties: Roanoke, Montgomery, Pulaski, Wythe, Smyth, Bland, Tazewell, Russell, Scott, and Albemarle. Of this number, only one county, Wythe, has shown as yet producing mines. More or less prospecting has been attempted in the majority of the counties named above, and small amounts of the ore have been mined in a number of them.

Geologically, the occurrence of lead and zinc ores in southwest Virginia is limited to the magnesian limestone of Cambro-Ordovician age, known as the Shenandoah or Valley limestone. The known commercial deposits of these ores occur near the eastern side of the Valley, though several promising prospects are opened near the western side.

The ores include (1) the original sulphide forms sphalerite (sulphide of zinc), galenite (sulphide of lead), pyrite (sulphide of iron), and in several places chalcopyrite (the double sulphide of iron and copper); and (2) the secondary or oxidized forms which have been derived from the original sulphides and occur in the residual clays derived by weathering from the limestone. These include calamine (hydrous silicate of zinc), smithsonite (carbonate of zinc), and cerussite (carbonate of lead). Named in the order of their importance, dolomite, calcite, barite, fluorite, and quartz are the associated non-metallic minerals.

The bulk of the sulphide ores belong to the disseminated replacement breccia type. Little or no replacement of the limestone by the ore is indicated in some places. The zones of breccia ore are associated with faulting and folding. Not all parts of the breccia zones are mineralized, but the ore is distributed at irregular intervals. The oxidized ores usually show much richness, and are often concentrated in massive form as large, irregular masses and layers, principally at and near the bottom of the residual clays, closely hugging the irregular weathered surface of the limestone. Until recently only the oxidized or secondary ores have been mined. These have been practically exhausted and attention is now directed to mining the original sulphide ores in the fresh limestone.

The ores are shipped to Pulaski, and smelted at the zinc smelting plant of the Bertha Mineral Company. Three grades of spelter are made, branded according to purity: "Bertha Pure Spelter," "Old Dominion," and "Southern."

The single deposit of lead and zinc ores in Albemarle County is the only type of its kind known in the South. The mine is owned by the Albemarle Zinc and Lead Company, and is located two miles slightly north of east from Faber. The associated rocks are metamorphic crystalline schists, cut by dikes of diorite and diabase. The metalliferous vein, traced for a distance of several miles, averages about four feet in width, strikes N. 45° E., and dips 80° to 85° northwest. Where opened, the vein is of the lenticular type, composed of bulbous bodies of fluorspar and some quartz through which the ore, blende and

galena, is distributed. The ore is treated in an 80-ton mill erected at the mine.

The production of lead in Virginia in 1908 was 76,190 pounds, valued at \$3,200. There was no production of lead or zinc reported from the Virginia mines in 1909. The production of zinc reported is to be credited to the reworking of old dumps. The 1910 production of lead amounted to 198,850 pounds, valued at \$8,750.

The production of spelter in Virginia in 1906 was 1,143 short tons, valued at \$139,446; in 1907, 771 short tons, valued at \$90,978; in 1908, 910 short tons, valued at \$85,540; in 1909, 58 short tons, valued at \$6,298; and in 1910, 794+ short tons, valued at \$85,758.

TIN.

Though not a producer of tin, the existence of tin ore in the Irish Creek area of Rockbridge County has been known for many years, and in 1883 and later the deposits were opened in several places. The Irish Creek area is about 4 miles long in a northeast-southwest direction and 3 miles wide, embracing a total area of 12 square miles. The immediate rocks of the area are of granitic composition, composed principally of a coarse aggregate of quartz and feldspar (orthoclase and albite), with hornblende, and in places some epidote. Dikes of fine-grained altered diabase cut the granitic rocks in all directions, and apparently are frequently associated with the tin-bearing veins.

The tin ore (cassiterite) occurs principally in greisen veins, which traverse the granite in all directions and have steep though varying dips. The veins are usually narrow, not exceeding a foot and less, though a greater thickness is frequent and some of the veins measure several feet across. The cassiterite is disseminated in small crystals and fine grains indistinguishable to the naked eye. The associated minerals comprise wolframite, mispickel (arsenopyrite), pyrite, and beryl. In addition to these, siderite, limonite, chlorite, muscovite, damourite, and fluorspar have been reported. The mispickel is reported by McCreath to contain both gold and silver.

NICKEL AND COBALT.

The existence of nickel in Virginia has been reported from a number of localities in the Piedmont region, especially in association with the extensive pyrrhotite bodies of the Floyd-Carroll-Grayson counties plateau in southwest Virginia, and in Amherst County east of Lynchburg. More recently nickel in association with peridotite masses has been reported from near Broadrun station in Fauquier County. In addition to the above occurrences, cobalt is found in association with some of the impure earthy manganese deposits of the Valley region, especially along the western base of the Blue Ridge.

Probably the most encouraging locality in the State from which nickel has been reported is in the northern part of Floyd County, where considerable exploratory work on Flat Run and Lick Fork has been carried on. The Lick Fork openings are the principal ones in the area, and the ore is chiefly pyrrhotite with some chalcopyrite. At the time of my visit in May, 1907, a large amount of ore on the dump was reported to average by actual assays not less than 1.75 per cent of nickel and a fraction of 1 per cent of copper. As much as 0.4 per cent of cobalt was reported, but the average is considerably less. Assays of the pyrite from other openings in the area are reported to yield from 3 to 4 per cent of nickel.

The rocks immediately associated with the ore are, without exception, of igneous origin, and comprise pyroxene syenite, diabase, and gabbro. These are intruded into the country schists and gneisses. The gabbro and diabase penetrate the pyroxene syenite in dike-like forms and are accordingly younger in age. The mica-gabbro is the ore-bearing rock. In some parts of the gabbro, the sulphides are sparingly present, in others they make up 50 per cent and more of the total rock mass, with all gradations between.

COAL.

The first coal mined in the United States was in the Richmond basin, where mines were opened and worked on the James River, near Richmond, as early as 1750. The production from the Richmond basin increased until 1832 (the production in 1828 being 100,280 tons), when it began to decline. In 1908, redevelopment of the mines at

Gayton by the Old Dominion Development Company was begun, and in 1910 a good production was reported by the company.

The construction of the Norfolk and Western Railway through southwest Virginia in 1882, opened up the famous Pocahontas coal district, which lies partly in Virginia. Likewise, the building of the Clinch Valley division of the Norfolk and Western Railway, nine years later, marked the beginning of the development of the Wise County coal district. The developments in these two fields in southwest Virginia, Tazewell County in 1883 and Wise County in 1891, restored Virginia to importance as a coal producer.

Coal was mined in the Montgomery-Pulaski counties area prior to the Civil War, but not in an extensive way. For a period of 30 years after the Civil War, the only mining carried on in this field was to supply a limited local market. Within recent years larger developments have been made, and until the beginning of the financial panic in the latter part of 1907, the production was correspondingly increased.

Coal is mined in two of the three major provinces of the State, namely, the Mountain province and the Piedmont province. Recent developments in the Piedmont province (Richmond coal basin) will undoubtedly restore this area again to the rank of an important producer.

The Virginia areas which have produced or are producing coal are as follows:

- I. The coal deposits of the Piedmont province. Includes the Richmond Coal Basin, which covers parts of the following five counties: Henrico, Chesterfield, Powhatan, Goochland, and Amelia. This is the only area of free-burning coal in the eastern portion of the United States that is located immediately adjacent to tidewater. The Farmville area, which covers parts of Prince Edward, Cumberland, and Buckingham counties.
- II. The coal deposits of the Mountain province, which include a number of separate areas extending across the State in a southwesterly direction from Frederick County on the north to the Tennessee boundary on the south.
 - (1) The Frederick County Area. Including the Mountain Falls district in the southwestern portion of the county and near the West Virginia line.
 - (2) The Augusta County Area. Includes the North River district in the northwest corner of Augusta County and the contiguous part of Rockingham County.

- (3) The Botetourt County Area. Includes the southwest corner of Botetourt County.
- (4) The Montgomery-Pulaski Counties Area. Includes Price and Brush mountains in Montgomery County, and Cloyd and Little Walker mountains in Pulaski County.
- (5) The Bland-Wythe Counties Area. Includes a small area in the southern part of Bland County and in the northern part of Wythe County.
- (6) The Southwest Virginia Area. Forms the southeastern portion of the Kanawha basin, and comprises the Pocahontas or Flat-Top and the Big Stone Gap coal fields of the following counties: Tazewell, Russell, Scott, Buchanan, Wise, and Lee.

Geologically, the Virginia coal deposits are grouped as (1) those of Triassic age, including the Richmond coal basin, and (2) those of Carboniferous age, which includes all coal deposits found west of the Blue Ridge. Of the Carboniferous coal deposits, those of the Mountain Falls district, in Frederick County, the North River area of Augusta County, the North Mountain area of Botetourt County, the Montgomery-Pulaski counties area, and the Bland-Wythe counties area are Mississippian (Lower Carboniferous) in age. The Virginia portion of the Appalachian coal field, which includes the extreme southwest counties along the border of West Virginia and Kentucky, and to which the State owes its rank as a coal producer, is Pennsylvanian (Upper Carboniferous) in age.

The southwest Virginia coal field forms the southwestern part of the Kanawha basin and comprises the following counties: Buchanan, Dickenson, Lee, Russell, Scott, Tazewell, and Wise. Of these, Wise, Tazewell, and Lee counties are the most important producers at present. The other counties contain large reserves of coal, which in places are rapidly undergoing development. This is especially true of Russell County, whose coal production increased more than 100 per cent in 1909. Many of these reserves have been made accessible recently through the construction of new lines of railroad, which means increased activity in coal mining in the State and a greater production in the immediate future.

It is due to the southwest Virginia fields that Virginia is entitled to rank among the principal coal-producing states. This area, the Virginia portion of the Appalachian coal field, is estimated to contain

1,550 square miles, with the original supply of coal placed at 22,500,000,000 short tons. Campbell and Parker state that from this there had been produced, at the close of 1907, a total of 57,229,152 short tons, representing an exhaustion of 86,000,000 tons. "The production in 1907 was 4,710,895 short tons, equivalent to an exhaustion of little over 7,000,000 tons, so that the coal left in the ground in Virginia at the close of 1907 was 2,000 times the exhaustion represented by the production of that year."

The Pocahontas and Big Stone Gap coal fields are the most extensively developed coal fields in the Virginia portion of the Appalachian region.

A goodly number of coal beds are found within the total vertical limits of the geological formations composing the Pocahontas field. Some of these are thin, but at least six workable beds have been opened in places. Not all of these are workable, however, at any one locality, and in places only one is worked. The superior quality of the Pocahontas coal has long established it as the best steam coal in the world. It produces an excellent coke, but, as a rule, the lump coal is placed directly upon the market for general purposes, while the slack and fine coal go direct to the ovens for coking.

The Big Stone Gap coal field in Virginia embraces parts of Lee, Scott, and Wise counties. Although opened up nearly ten years after the famous Pocahontas field, it is much the largest producer of coal and coke, and Wise County is the largest coal- and coke-producing county in the State. Wise County contributes at present about 60 per cent of the State's total coal production.

There are eight workable seams of coal in the district, ranging in thickness from 3.5 to 12 feet, included within a vertical distance of about 1,200 feet. Of these, the four highest have their greatest development in the western part of the district.

The coal mining industry in Virginia showed a marked increase during the years 1909 and 1910 over that of previous years. Virginia was one of the few states whose production in 1909 exceeded that of 1907, which was due to the increased production in Wise County and to active development in Russell County. The production in Wise County increased from 2,558,874 short tons in 1908 to 2,841,448 tons

in 1909. Russell County's production increased more than 100 per cent. The production in Tazewell County was 4,349 tons less in 1909 than in 1908, and in Lee County 15,117 tons less in 1909. The total production in Virginia for 1909 amounted to 4,752,217 short tons, valued at \$4,251,056, as compared with 4,259,042 short tons, valued at \$3,868,524, in 1908. This represents an increase in quantity of 493,175 short tons, or 11.5 per cent, and in value of \$382,502. The average price per ton was 89 cents in 1909 against 91 cents in 1908 and \$1.02 in 1907. The number of mining machines increased from 85 in 1908 to 107 in 1909, and the machine-mined coal increased from 1,035,832 tons to 1,323,111 tons, nearly 30 per cent of the total quantity of coal mined in 1909. None of the Virginia coal is washed before being sold or used.

Virginia established a new record in her coal production in 1910. The production in Lee, Russell, Tazewell, and Wise counties showed a marked increase in 1910 over that of the previous year, due to the considerable development in progress, not so much in the way of new companies, but in the expansion of properties already developed. This is particularly true of Russell County. The reason for the increased production in 1910 over that of 1909 was indirectly the strike in the coal mines of Illinois and the southwestern States.

The production in Tazewell County increased from 975,665 short tons in 1909 to 1,187,146 short tons in 1910; in Wise County from 2,841,448 short tons in 1909 to 3,730,992 short tons in 1910; and in Lee County from 485,960 short tons in 1909 to 792,763 short tons in 1910. The total production of coal in Virginia during 1910 amounted to 6,507,997 short tons, valued at \$5,877,486, representing an increase over the 1909 production of 1,755,780 short tons in quantity, and \$1,626,430 in value. This is the largest tonnage of coal ever produced in Virginia during a single year. The average price per ton of coal in the State during 1910 was 90 cents as against 89 cents in 1909. The number of mining machines increased from 107 in 1909 to 142 in 1910, and the machine-mined coal increased from 1,323,111 short tons to 2,290,435 short tons, more than 35 per cent of the total quantity of coal mined in 1909.

The accompanying table gives the quantity and value of coal produced in Virginia from 1890 to 1910, inclusive.

Quantity and value of Coal produced in Virginia, 1890 to 1910, inclusive.

Year	Quantity (short tons)	Value
1890.....	784,011	
1891.....	736,399	
1892.....	675,205	
1893.....	820,339	
1894.....	1,299,083	
1895.....	1,368,324	
1896.....	1,254,723	\$ 848,851
1897.....	1,528,302	1,021,918
1898.....	1,815,274	1,070,417
1899.....	2,105,791	1,304,241
1900.....	2,393,754	2,123,222
1901.....	2,725,873	2,353,989
1902.....	3,182,993	2,543,595
1903.....	3,451,307	3,302,149
1904.....	3,583,914	3,076,011
1905.....	4,275,271	3,777,325
1906.....	4,254,879	4,183,991
1907.....	4,710,895	4,807,533
1908.....	4,259,042	3,868,524
1909.....	4,752,217	4,251,056
1910.....	6,507,997	5,877,486

There is given in the table below the production of coal in Virginia from 1900 to 1910, by counties.

Coal Production of Virginia, 1900-1910, by counties, in short tons.

County	1900	1901	1902	1903	1904
Montgomery	9,814	11,177	12,786	20,288	.....
Tazewell	970,866	776,568	723,753	840,195	871,720
Wise	1,363,570	1,918,693	2,422,417	2,563,285	2,359,661
Chesterfield }				18,084	2,100
Henrico }	49,504	19,435	24,037 ^a		
Pulaski				9,255	177,133 ^b
Russell					
Lee					
Small mines				200	300
Total	2,393,754	2,725,873	3,182,993	3,451,307	3,410,914
Total value.....	\$2,123,222	\$2,353,989	\$2,543,595	\$3,302,149	\$3,302,149

Coal Production of Virginia, 1900-1910, by counties, in short tons.—
Continued.

1905	1906	1907	1908	1909	1910
961,380	910,638	1,116,534	6,022	(d)	(d)
2,990,698	3,041,225	3,145,846	980,014	975,665	1,187,146
			2,558,874	2,841,448	3,730,992
323,073 ^c	302,896 ^c	448,515 ^c	249,671	(d)	(d)
				(d)	(d)
120			464,261	449,144	797,096
			200	485,960 ^e	792,763 ^f
4,275,271	4,254,879	4,710,895	4,259,042	4,752,217	6,507,997
\$3,777,325	\$4,183,991	\$4,807,533	\$3,868,524	\$4,251,056	\$5,877,486

^aIncludes Chesterfield and Pulaski counties.^bIncludes Montgomery County.^cIncludes Lee and Montgomery counties.^dIncluded under "Small mines."^eIncludes Montgomery, Pulaski, and Russell counties.^fIncludes Montgomery, Henrico, Pulaski, and Russell counties.

LIST OF COAL OPERATORS

OPERATOR	OFFICE	MINE
American-Pocahontas Coal Co.	Washington, D. C.	American-Pocahontas
Barrowman Coal Co.	Banner	Spruce Pine
Beacham Coal Co.	Christiansburg	Beacham
Belle Hampton Coal Mining Co.	Binghampton, N. Y.	Belle Hampton
Big Vein Pocahontas Coal Co.	Baltimore, Md.	Big Vein Nos. 1 & 2
Black Mountain Collieries Co., Inc.	Pennington Gap	Black Mountain No. 1
Black Mountain Mining Co.	Big Stone Gap	Black Mountain
Blackwood Coal & Coke Co.	Blackwood	Blackwood and Roaring Fork
Bond Coal Co.	Tacoma	Greeno
Bondurant Coal & Coke Co.	Pennington Gap	Bondurant
Browning, James S.	Pocahontas	Browning
Bruce Coal & Coke Co.	Tacoma	Bruce
Buchanan Coal & Coke Co.	Richmond	Prospect
Catawba Mining & Mfg. Co.	Roanoke	
Chesterfield Coal Co.	Winterpock	Clover Hill
Clinchfield Coal Corporation	Dante and Johnson Cranes Nest City, Tenn.	
Clinch River Coal Co.	Richlands	Clinch River
Clinch Valley Lumber Co.	St. Paul	
Colonial Coal & Coke Co.	Dorchester	Dorchester
Darby Coal & Coke Co.	Cincinnati, Ohio	Darby
Dickenson, W. E.	Coeburn	
Dixie Coal & Coke Co.	Raven	Dixie
Domestic Coal Co.	Raven	Domestic
Dominion Coal Co.	Pennington Gap	Blanche, Early, Mabel Edgar, and Susie Ferge
Empire Coal Land Corporation	Alfredton	Seaboard
Esser Coal & Coke Co.	Esserville	Esserville

OPERATOR	OFFICE	MINE
Fleming & Co., Robert.....	Norton	Banner
Goodloe Bros. Co., Inc.....	Big Stone Gap.....	Pin Hook
Hale, J. E.....	Wise	
Huettel Coal & Coke Co.....	Norton	Huettel
Hyndman Coal & Coke Co.....	Norton	Carlson
Imboden Coal & Coke Co.....	Imboden	Imboden
Intermont Coal & Iron Co. (Kelly & Irvine).....	Big Stone Gap.....	Josephine
James River Coal Corporation.....	Midlothian	Midlothian
Jewell Ridge Coal Co.....	Tazewell	Jewell Ridge
Keokee Consolidated Coke Co.....	New York, N. Y.....	Imboden, Keokee
Kinzer & Son.....	Vicar Switch	Stroubles Creek
Lee Coal Co.....	Middlesboro, Ky.....	Lee
Lick Branch Anthracite Coal Co.....	Christiansburg	
Litz, J. L.....	Coeburn	
Monarch Coal Co., Inc.....	Cincinnati, Ohio	Leona
Norton Coal Co.....	Norton	Norton, Nos. 1, 2, and 3
Old Dominion Development Co.....	Richmond	Carbon Hill
Pennington Coal Co., Inc.....	Pennington Gap	Pennington
Pocahontas Consolidated Collieries Co.....	Pocahontas	Boissevain and Pocahontas
Pocahontas Mining Corporation.....	Tazewell	Big Creek
Pound River Coal Corporation.....	Wise	Pound River
Price Bros	Cambria	Blacksburg Mng. & Mfg. Co.
Price Mountain Coal Co. (Bandy, Warren & Hawser).....	Roanoke	Myers
Pulaski Anthracite Coal Co.....	New York, N. Y.....	Parrott
Raven Collieries Co.....	Raven	Coal Creek
Raven Fuel Co.....	Raven	Red Ash
Raven Red Ash Coal Co.....	Red Ash	Red Ash
Richlands Coal Co.....	Richlands	Richlands
St. Paul Coal & Coke Co.....	St. Paul	St. Paul
Scott County Mineral Co.....	Bristol, Tenn	
Slusser & Co., M. C.....	Blacksburg	Brush Mountain
Smith & Co., H. P.....	Blacksburg	Snider Hill
Southern Anthracite Coal Co.....	Roanoke	Clear Air
Southern Pocahontas Coal Co.....	Richlands	Sater
Stonega Coke & Coal Co.....	Big Stone Gap	Arno, Nos. 1 and 2; Crossbrook, Osaka; Roda, and Stonega
Stonegap Colliery Co.....	Glamorgan	Glamorgan
Sutherland Coal & Coke Co.....	Dorchester	Sutherland
Tacoma Coal & Coke Co.....	Tacoma	Tacoma
Town Hill Coal Co., W. R. Williams.....	Bramwell, W. Va.....	Town Hill
Trigg & Kent.....	Bristol, Tenn	T. & K.
Virginia Anthracite Coal Co.....	Richmond	Merrimac
Virginia City Collieries Co.....	Virginia City	Virginia City
Virginia Iron, Coal & Coke Co.....	Roanoke	Coeburn, Inman, Lee, Linden, Looney Creek, Marion, Pine Run, Swansea, Sexton, and Thelma
Virginia Lee Co., Inc.....	Pennington Gap	St. Charles and Virginia Lee
Virginia-Tennessee Coal Co.....	Knoxville, Tenn	Coal Creek
Wise Coal & Coke Co.....	Dorchester	Wise
Yellow Creek Coal & Coke Co., Inc.....	Wise	Yellow Creek

COKE.

The coking coals of Virginia are confined to a few counties in the extreme southwestern portion of the State. The rapid development of the coking-coal fields in this portion of the State during the last few years has given Virginia rank as one of the four principal coke-producing states. Prior to 1895, there were only two coke-making establishments in Virginia, with a production of less than 200,000 tons per year. The number of establishments increased to seven in 1901, and the total number of coke ovens increased from 832 in 1896, to 2,775 in 1901, with a total production of more than 900,000 short tons. Construction and development work progressed rapidly during 1902, the number of establishments was doubled, and, at the close of the year, 2,974 ovens were built and 1,208 were building, with the production increased 1,124,572 short tons.

In 1903, two more establishments were added, making the total number 16, with a total of 4,251 ovens, and the production further increased to 1,176,439 short tons. In 1904, there was an increase of 94 completed ovens, the number of establishments remaining the same as in 1903, while the production declined to 1,101,716 short tons. Two establishments having a total of 107 ovens were reported idle during the year 1904. One of these was the Newton-Chambers ovens at Pocahontas in Tazewell County.

The production of coke in 1905 amounted to 1,499,481 short tons, valued at \$2,869,452, as compared with 1,101,716 short tons, valued at \$1,772,717 in 1904, an increase of 36.1 per cent in quantity, and 62 per cent in value. The number of ovens increased from 4,345 in 1904 to 4,549 in 1905, an increase of 204.

There were 18 establishments in 1906, an increase of two over 1905, and the total number of ovens increased from 4,549 to 4,641 in 1906. The production increased from 1,499,481 short tons in 1905, valued at \$2,869,452, to 1,577,659 short tons, valued at \$3,611,659. The value of coke at the ovens increased from \$1.91 per ton to \$2.29.

In 1907, the production of coke decreased from 1,577,659 short tons in 1906, to 1,545,280, a loss of 32,379 tons, or 2.1 per cent. Owing, however, to better prices which prevailed in 1907, the value of the coke produced increased from \$3,611,659 in 1906 to \$3,765,733

in 1907, an increase of \$154,074, or 4.3 per cent. There were 19 establishments in 1907, an increase of one over 1906, and the number of ovens increased from 4,641 to 5,333 in 1907.

The monetary troubles in the latter part of 1907 very seriously effected the coke industry in the State during 1908. There was a decrease in the amount of coke from 1,545,280 short tons in 1907 to 1,162,051 tons in 1908, a loss of 383,229 tons, or 24.8 per cent; and, in value, a decrease from \$3,765,733 in 1907 to \$2,121,980 in 1908, a loss of \$1,643,753, or 43.65 per cent. The value of coke at the ovens decreased from \$2.44 per ton in 1907 to \$1.83 in 1908. The number of establishments (19) remained the same as for 1907, but there was a decrease in ovens from 5,333 to 4,853 in 1908.

The production of coke in Virginia during 1909 was 1,347,478 short tons, valued at \$2,415,769, which represented an increase over the production for the previous year, of 185,427 tons in quantity and \$293,789 in value. The number of ovens reported in existence was 5,469; number building, 100. The value of coke per ton was \$1.79 as compared with \$1.83, the value per ton in 1908.

The production of coke in Virginia during 1910 was 1,493,655 short tons, valued at \$2,731,348, which represented an increase over the production for 1909 of 146,177 tons, or 10.9 per cent, and \$315,579, or 13.1 per cent, in value. The number of establishments was reduced from 19 to 18 and the number of ovens from 5,469 to 5,389. There were 100 beehive ovens in course of construction at the close of 1910. The value of coke per ton increased from \$1.79 in 1909 to \$1.83 in 1910.

The principal part of the coke production in Virginia during the last few years has been from the development of the coal fields in Wise County, on the Clinch Valley division of the Norfolk and Western Railway. During 1906 and 1907 extensive developments were made in the Black Mountain field in Lee County following the construction of the Black Mountain railroad. The first ovens in Lee County were reported under construction in 1907, with an output in 1908 of 50,000 tons, which was increased to over 100,000 tons in 1909, but decreased to 86,000 tons in 1910. The production in other districts increased during 1910, and the total output for the State showed an

increase of 146,177 tons, or 10.9 per cent, and in value of \$315,579, or 13.1 per cent. The average price per ton advanced from \$1.79 in 1909 to \$1.83 in 1910. The coal for the plant at Lowmoor and the one at Covington is drawn from the mines in the New River district of West Virginia, and that for the ovens at Pocahontas in Tazewell County is obtained from mines extending across the State boundary into West Virginia.

Of the 1910 production of coke in Virginia, 1,025,144 short tons of the total tonnage (1,493,655) came from Wise County. The value of the production from Wise County was \$1,883,344. In order to avoid disclosing individual figures, it is not possible to publish the production of the other counties producing in 1910. These counties, however, listed in order of productions were: Roanoke, Tazewell, and Alleghany.

In the subjoined table are shown the statistics of the manufacture of coke in Virginia in 1883, when the first operations were begun, in 1890, 1900, and from 1903 to 1910, inclusive.

Statistics of the manufacture of Coke in Virginia, 1883-1910.

Year	Estab- lish- ments	Ovens		Coal used (short tons)	Coke produced (short tons)	Total value of coke at ovens
		Built	Building			
1883	1	200	0	39,000	25,340	\$ 41,345
1890	2	550	250	251,683	165,847	278,724
1900	7	a2,331	300	1,083,827	685,156	1,464,556
1903	16	a4,251	142	1,860,225	1,176,439	2,724,047
1904	16	a4,345	68	1,636,905	1,101,716	1,772,717
1905	16	a4,549	0	2,184,369	1,499,481	2,869,452
1906	18	a4,641	695	2,296,227	1,577,659	3,611,659
1907	19	a5,333	50	2,264,720	1,545,280	3,765,733
1908	19	4,853	158	1,785,281	1,162,051	2,121,980
1909	19	5,469	100	2,060,518	1,347,478	2,415,769
1910	18	a5,389	100	2,310,742	1,493,655	2,731,348

^aIncludes 56 Newton-Chambers by-products ovens.

All the coal used in coke-making in Virginia up to 1895 was un-washed. Washing of slack coal began in 1896, and in 1898 the amount of washed slack coal used amounted to 210,000 short tons. All the coal

used in the manufacture of coke in the State during the years 1909 and 1910 was unwashed. Of the 2,310,742 short tons of coal made into coke during 1910, 1,554,784 tons were run-of-mine and 755,958 tons were slack.

The character of the coal used in coke-making in Virginia during 1890, 1900, and from 1903 to 1910, inclusive, is shown in the table below.

*Character of Coal used in the manufacture of Coke in Virginia,
1890-1910, in short tons.*

Year	Run-of-Mine		Slack		Total
	Unwashed	Washed	Unwashed	Washed	
1890	98,215	0	153,468	0	251,683
1900	620,207	0	463,620	0	1,083,827
1903	857,332	0	1,002,893	0	1,860,225
1904	1,213,226	44,222	379,457	0	1,636,905
1905	1,096,656	0	1,087,713	0	2,184,369
1906	1,014,299	228,347	1,053,581	0	2,296,227
1907	1,271,518	0	993,202	0	2,264,720
1908	1,438,754	0	346,527	0	1,785,281
1909	1,405,111	0	655,407	0	2,060,518
1910	1,554,784	0	755,958	0	2,310,742

LIST OF COKE OPERATORS

OPERATOR	OFFICE	MINE
Blackwood Coal & Coke Co.	Blackwood	Blackwood
Colonial Coal & Coke Co.	Dorchester	Dorchester
Empire Coal Land Corporation	Alfredton	Alfredton
Esser Coal & Coke Co.	Esseville	Norton
Hyndman Coal & Coke Co.	Norton	Hyndman
Imboden Coal & Coke Co.	Imboden	Imboden
Intermont Coal & Iron Co.	Big Stone Gap	Near Norton
Keokee Consolidated Coke Co.	New York, N. Y.	Imboden and Keokee
Lowmoor Iron Co. of Virginia....	Lowmoor	Covington and Lowmoor
Norton Coal Co.	Norton	Norton
Pocahontas Consolidated Collieries Co.	Pocahontas	Pocahontas
Stonega Coke & Coal Co.	Stonega, Osaka, and Imboden	Stonega, Osaka, and Imboden, Osaka, and Philadelphia, Pa.
Stonegap Colliery Co.	Glamorgan	Glamorgan
Sutherland Coal & Coke Co.	Dorchester	Manning
Virginia Iron, Coal & Coke Co.	Roanoke	Toms Creek and Inman
Wise Coal & Coke Co.	Dorchester	Dorchester

CLAYS AND CLAY PRODUCTS.

Virginia contains a variety of clays widely distributed and occurring at various geological horizons. They are found abundantly distributed throughout the Coastal Plain, Crystalline, and Mountain provinces of the State, and are adapted to a wide range of uses. Many of the deposits remain undeveloped, because they have not yet been investigated, and little is known regarding them. The only ones which have been systematically studied are those of the Coastal Plain or Tidewater region.

The clays of Virginia are suitable for many economic purposes, and can be divided into two groups, namely, residual and sedimentary. The residual clays have been formed by the weathering of rocks, involving processes of disintegration and decomposition. As a result of this, we find the residual clays overlying the parent rocks from which they were derived, forming deposits of variable thickness, depending partly on the depth to which the rocks have been changed, and partly on the amount of erosion they have suffered since their formation. Residual clays predominate in the belt (Piedmont region) underlain by the crystalline rocks, such as granites, gneisses, schists, etc., and have wide distribution west of the Blue Ridge. They are usually quite ferruginous and, therefore, red-burning. Their main use is for the manufacture of brick and drain tile, and some of the smoother deposits have been employed for making smoking pipes, notably those of Powhatan County.

The decomposition of pegmatite dikes in many of the Piedmont counties has yielded clays of high grade, free from iron, and sometimes sufficiently white to be used for the manufacture of white-ware products. Deposits of this type, known as kaolin, have been found in Amherst, Campbell, Hanover, Henry, Mecklenburg, Nelson, Patrick, and other counties in the Piedmont region.

The sedimentary clays represent deposits which have been laid down under water, one layer on another, the materials composing them consisting of the products of rock decay, which have been removed by erosion from the land surface, and washed down into the lakes or seas, where they have finally settled. These are abundant in both the

Coastal Plain province, where they are usually of unconsolidated character, and west of the Blue Ridge, in which region they are largely of a hard and shaly nature. They have wide distribution both geologically and geographically.

The Coastal Plain clays that have proved to be of marked value to the clay worker, occur in Eocene and Miocene beds of the Tertiary, and the Pleistocene of the Quaternary. The Eocene clays are best developed in the region south of Stafford Courthouse, where they form promising outerops, but have not yet been developed. The Miocene clays are best known south of Richmond, in the vicinity of Curle's Neck, and Bermuda Hundred. This same formation also carries extensive beds of diatomaceous earth or clay, which is well exposed at Richmond and along the Rappahannock River. The Pleistocene clays occur as more or less basin-shaped deposits, widely scattered over the Coastal Plain region, and rest on top of the other formations.

Nearly all of the clay deposits noted in the Coastal Plain region, whatever their geological age, are of lenticular or lens-shaped character. The majority of them are red-burning, while only a few are buff-burning. No white-burning clays have thus far been found; but even though they lack in variety, so far as their color-burning qualities are concerned, it is probable that their possible uses are more numerous than is now supposed. Physical tests and chemical analyses of the clays in Tidewater Virginia are given in Bulletin I-A of the Virginia Geological Survey.

West of the Blue Ridge, in the Mountain province, shales probably suitable for brick-making have wide distribution, ranging in age from Cambro-Ordovician to Carboniferous. Many of these shale deposits will doubtless prove available for the manufacture of vitrified brick.

The abundant deposits of Virginia clays are only partially utilized at present, but, after their thorough investigation by the State Geological Survey and their uses better made known, they will be much more extensively employed and the industry greatly enlarged or expanded.

In 1909, the total value of all clay products manufactured in Virginia, including the value of kaolin, pottery products, fire clay, and miscellaneous clay mined and sold in the State, amounted to

\$1,957,367. Compared with the value (\$1,540,157) of the 1908 production, there was an increase of \$417,210 or nearly 27 per cent.

In 1910, the total value of all clay products manufactured in Virginia was \$1,841,731, a decrease from that of 1909 of \$115,636.

The following table gives the statistics of clay products in Virginia from 1905 to 1910, inclusive, and is of interest to those who desire to know something of the growth of the industry in the State. The item "Miscellaneous" in the table includes all products not otherwise specified (fire brick, sewer pipe, drain tile, fancy or ornamental brick, kaolin, and pottery products), and those which could not be published separately without disclosing individual returns.

Clay Products in Virginia from 1905 to 1910, inclusive.

Product	1905	1906	1907
Brick:			
Common—			
Quantity	237,161.000	232,697,000	197,052,000
Value	\$1,572,442.00	\$1,536,312.00	\$1,285,374.00
Average per thousand.....	\$6.63	\$6.60	\$6.52
Vitrified—			
Quantity	(a) .....	.....	.....
Value	(a) .....	.....	.....
Average per thousand.....	\$10.00	.....	.....
Fire—			
Quantity	22,155.000	25,385,000	19,989,000
Value	\$352,297.00	\$392,130.00	\$290,411.00
Average per thousand.....	\$15.90	\$15.45	\$14.53
Fancy or ornamental. Value.....	\$20,363.00	(a)	(a)
Fire. Value	(a)	\$21,110.00	(a)
Drain tile. Value.....	\$4,500.00	\$4,805.00	\$6,250.00
Sewer pipe. Value .....	.....	.....	.....
Pottery:			
Earthenware and stoneware. Value.....	.....	.....	.....
Porcelain electrical supplies. Value.....	(b)	(b)	(b)
Miscellaneous. Value	\$44,976.00	\$11,721.00	\$29,300.00
Total value	\$1,994,578.00	\$1,966,078.00	\$1,611,335.00
Number of operating firms reporting..	94	91	87

aIncluded in miscellaneous.

bThe value of pottery products for Virginia from 1905 to 1910, inclusive, is included under miscellaneous.

Clay Products in Virginia from 1905 to 1910, inclusive.—Continued.

Product	1908	1909	1910
Brick:			
Common—			
Quantity	185,738,000	249,794,000	229,982,000
Value	\$1,219,946.00	\$1,540,648.00	\$1,460,460.00
Average per thousand.....	\$6.57	\$6.13	\$6.35
Vitrified—			
Quantity .....	.....	.....	.....
Value .....	.....	.....	.....
Average per thousand.....	.....	.....	.....
Front—			
Quantity	17,858,000	24,717,000	20,813,000
Value	\$246,623.00	\$333,057.00	\$294,348.00
Average per thousand.....	\$13.81	\$13.48	\$14.14
Fancy or ornamental. Value.....	(a)	(a)	(a)
Fire. Value	(a)	(a)	(a)
Drain tile. Value.....	\$7,100.00	\$6,298.00	\$5,276.00
Sewer pipe. Value .....	.....	(a)	(a)
Pottery:			
Earthenware and stoneware. Value.....	.....	.....	.....
Porcelain electrical supplies. Value.....	(b)	(b)	(b)
Miscellaneous. Value	\$66,488.00	\$77,364.00	\$81,647.00
Total value	\$1,540,157.00	\$1,957,367.00	\$1,841,731.00
Number of operating firms reporting..	82	89	87

^aIncluded in miscellaneous.^bThe value of pottery products for Virginia from 1905 to 1910, inclusive, is included under miscellaneous.**BRICK CLAYS.**

Clays suitable for the manufacture of common and front brick, particularly the former, are widely distributed throughout the State. In fact, nearly every county in Virginia contains clay suitable for the manufacture of common brick, and, in most cases, the deposits are of such character that common brick of the best quality can be made. The brick-yards can be located usually near railroad transportation, and fuel for burning the brick can be obtained, as a rule, at a minimum price. Virginia clays used in the manufacture of common brick are of two types, residual and sedimentary, discussed on page 50.

The total number of common and front brick manufactured in Virginia in 1909 was 274,511,000, valued at \$1,873,705, as against 203,596,000, valued at \$1,466,569 in 1908, an increase of 70,915,000

in quantity and \$407,136,000 in value. Of the 1909 production, 249,794,000 were common brick, valued at \$1,540,648, and 24,717,000 front brick, valued at \$333,057. The average value per thousand of the 1909 production was: Common brick, \$6.13, front brick, \$13.48.

During 1910, the total number of common and front brick manufactured in Virginia was 250,795,000, valued at \$1,754,808, as against 274,511,000, valued at \$1,873,705 in 1909, a decrease of 23,716,000 in quantity, and \$118,897 in value. Of the 1910 production, 229,982,000 were common brick, valued at \$1,460,460, and 20,813,000 front brick, valued at \$294,348. The average value per thousand of the 1910 production was: Common brick \$6.35, front brick \$14.14.

The total value of fancy or ornamental brick and of fire brick produced in Virginia in 1909 was \$30,984, and in 1910, \$24,186. The quantity and value of the different varieties of brick manufactured in Virginia during 1909 and 1910 are given in the tables below.

In the tables below are given the total number and value of common and front brick manufactured in Virginia in 1909 and 1910, by counties.

Production of Common and Front Brick in Virginia in 1909, by counties.

County	Common Brick		Front Brick	
	Quantity (Thousands)	Value	Quantity (Thousands)	Value
Alexandria	75,874	\$ 462,137	24,265	\$ 327,083
Augusta	1,120	9,600		
Chesterfield	15,790	102,231		
Fairfax	9,125	57,584		
Henrico	31,728	201,600		
Nansemond	16,692	97,718		
Roanoke	15,019	94,687		
Rockingham	2,650	17,500		
Other counties	81,796 ^a	497,591 ^a	452 ^b	5,974 ^b
	249,794	\$1,540,648	24,717	\$333,057

^aIncludes Albemarle, Alleghany, Brunswick, Campbell, Carroll, Charles City, Charlotte, Culpeper, Frederick, Grayson, Greenesville, Halifax, Henry, Isle of Wight, King George, Lancaster, Lee, Lunenburg, Montgomery, Norfolk, Nottoway, Orange, Pittsylvania, Prince George, Princess Anne, Rockbridge, Russell, Scott, Shenandoah, Spotsylvania, Sussex, Tazewell, and Warwick.

^bIncludes Halifax, Henrico, and Rockingham.

Production of Common and Front Brick in Virginia in 1910, by counties.

County	Common Brick		Front Brick	
	Quantity (Thousands)	Value	Quantity (Thousands)	Value
Alexandria	65,484	\$ 415,551		
Augusta	925	7,300		
Chesterfield	9,115	60,644		
Fairfax	7,595	60,100		
Henrico	20,763	141,844		
Nansemond	16,771	99,545		
Roanoke	17,300	104,600		
Rockingham	92,029 ^a	570,876	20,813 ^b	\$294,348
Other counties	229,982	\$1,460,460	20,813	\$294,348

^aIncludes Albemarle, Alleghany, Amherst, Brunswick, Campbell, Caroline, Carroll, Charles City, Charlotte, Culpeper, Frederick, Grayson, Halifax, Henry, Isle of Wight, James City, King George, Lancaster, Montgomery, Norfolk, Nottoway, Orange, Pittsylvania, Princess Anne, Powhatan, Rockbridge, Russell, Scott, Shenandoah, Smyth, Spotsylvania, Sussex, Tazewell, and Warwick.

^bIncludes Alexandria, Halifax, Henrico, James City, Pittsylvania, and Powhatan.

FIRE CLAYS.

Refractory clays are known to occur in many localities of the State, but they have not yet been investigated, and the production is small and variable. It is highly probable that the clayey members, including shales of the Carboniferous system of rocks, occurring west of the Blue Ridge and having the most extensive development in southwest Virginia, will prove of sufficient value for making vitrified wares. The Triassic shales associated with the coals of the Richmond basin have not proved of any value for the manufacture of clay products. Clays of the refractory type occur in a number of the Piedmont counties, and have been worked at several localities in some of these.

The production of fire clay during 1909 and 1910 was small and is included under "Miscellaneous" in the table on page 53.

POTTERY CLAYS.

The pottery industry in Virginia is a small one. The total value of pottery products made in Virginia in 1909 amounted to \$36,746, as against \$37,777 in 1908. This represents a decrease of \$1,031. The value of pottery products made in the State during 1910 is included under "Miscellaneous" in the table on page 53.

KAOLIN.

The production of kaolin in Virginia has been derived almost entirely from the decomposed pegmatite dikes, which intersect the crystalline rocks of the Piedmont region. Deposits of this type have been worked in Amelia, Henry, and Nelson counties, and are known to occur but not developed in many other of the Piedmont counties. Of these, Henry is the principal producing county at present.

The production of kaolin in Virginia is small, and is included under "Other products" in the tables on pages 5 and 6, showing the mineral production in Virginia for the years 1909 and 1910.

LIST OF CLAY OPERATORS

OPERATOR	OFFICE	BRICK AND TILE	
		WORKS	
Adams Bros. Co., Inc.....	Bristol	Bristol	
Adams Bros.-Paynes Co., Lynchburg Brick Works, Props	Lynchburg	Deacon	
Alleghany Brick Co., Inc.....	Covington	Covington	
Altavista Brick Co., Inc. (Formerly Fra-zier Lbr. Co.).....	Altavista	Altavista	
Baltimore Brick Co.....	Richmond	Rocketts	
Barr, E. M.....	Winchester	Winchester	
Bell Bros	Strasburg	Strasburg	
Billheimer, W. H.....	Harrisonburg	Harrisonburg	
Blackburn & Loehr.....	Staunton	Staunton	
Bolling, Thomas A.....	Farmville	Farmville	
Booker Brick Co.....	Newport News	Morrison	
Boston Brick Co.....	Houston	Houston and South Bos-ton	
Brister, C. M.....	Petersburg	Ettricks (near)	
Brooks & Son, A. M.....	New River	Radford	
Bromilaw Brick Co.....	Alexandria	Hunting Creek	
Buck & Co., Levin T.....	Weems	Weems	
Burroughs & Mankin, Inc.....	Richmond	Manbur	
Butler, Geo. W.....	Culpeper	Culpeper	
Capital Brick & Tile Corporation.....	Washington, D. C.....	Alexandria	
Champe, John A.....	Lexington	Lexington	
Charlottesville Brick Co.....	Charlottesville	Charlottesville	

OPERATOR	OFFICE	WORKS
Cheatwood & Blunt	Richmond	Brook Read
Clarke & Covington	Culpeper	Elkwood
Clark & Crupper	Washington, D. C.	Arlington
Cole & Son, W. C. (Formerly Galax Brick Co.)	Galax	Galax
Cooley Bros., Smith & Co.	Marion	Marion
Copping, H. B.	Chase City	Chase City
Corlton, W. H.	Manchester	Manchester
Covington Brick Co. (Formerly Isaac Clark)	Covington	Covington
Coyner, J. M.	Basic City	Basic City
Croghan, Daniel	Staunton	Staunton
Croushorn, B. G. Lessee of H. V. Croushorn Prop.	Weyers Cave	Weyers Cave
Crowell W. H.	Bristol	Bristol
Cuthbert Land & Development Co.	Wiehle	Wiehle
Davis Brick Co., Inc., W. Benjamin	Richmond	Manchester
Dickinson Fire Brick Co.	Buena Vista	Buena Vista
Eureka Brick Co.	Norfolk	Lynnhaven
Face & Son, E. W.	Norfolk	Norfolk
Fellers Stone Co., Inc.	Roanoke	Roanoke
Fitzgerald, N. A. & T. J.	Danville	Danville
Ford & Wells	Lynchburg	Lynchburg
Franklin Brick Co.	Franklin	Franklin
Frazier, W. R.	Suffolk	
Fredericksburg Brick Works	Fredericksburg	Fredericksburg
Fulton Brick Works	Richmond	Richmond
Gardner, John W.	Mt. Airy, N. C.	Woodlawn
Gilmore, W. J.	Louisa	Louisa
Grinder, E. M.	Washington, D. C.	Rosslyn
Haden, George P. (Formerly B. D. Linney)	Blackstone	Blackstone
Hamblick, S. G.	Lebanon	Barnett
Harrison Construction Co.	Petersburg	Petersburg
Hatcher & Gaither	Orange	Orange
Hicks Brick Co.	Lawrenceville	Lawrenceville
Hoffman, Geo. E.	Culpeper	Culpeper
Holdaway, R. L. (Formerly W. E. Sutherland)	Major	Bridle Creek
Hoshour & Son, John S.	Woodstock	Woodstock and Front Royal
Hoskins, D. W.	South Boston	South Boston
Huffman & Son, J. S.	Buena Vista	Buena Vista
Hurley, S. R.	Grundy	Grundy
Hydraulic-Press Brick Co.	Washington, D. C.	Waterloo
Johnson, W. C.	Spencer	Johnson's Siding
Jones, W. L.	Williamsburg	James City
Keeler & Son, G. B.	Petersburg	Broadway
Kenbridge Brick Co.	Kenbridge	Kenbridge
Lawrenceville Brick & Tile Co., Inc.	Norfolk	Lawrenceville
Layfield, F. G. (Formerly Oldfield Brick & Tile Co., Inc.)	Oldfield	Oldfield
Lemley & Sons, L. F.	Strasburg	Strasburg
Lunenburg Brick & Tile Co.	Kenbridge	Kenbridge
Mayo & Sons, W. R.	Norfolk	Sturgeon Point
Moistproof Pressed Brick Co.	Norfolk	Norfolk
Montgomery Brick Co.	Christiansburg	Christiansburg

OPERATOR	OFFICE	WORKS
Mulberry Island Brick Co.	Newport News	Mulberry Island
Musser & Son, W. H.	Abingdon	Emory
Myers, Jacob S.	Harrisonburg	Harrisonburg
Nalle, Orville	Elkwood	Elkwood
Nansemond River Brick & Tile Co.	Norfolk	Reid's Ferry
New Washington Brick Co.	Washington, D. C.	Abingdon
Norton Brick Co.	Norton	Norton
Oyster Point Brick Co.	Oyster Point	Oyster Point
Patuxent Brick Co.	Washington, D. C.	Alexandria
Payne & Spindler	Drakes Branch	Drakes Branch
Phillips & Bro., C. H.	Hampton	Hampton
Pierpont Brick Works	Salem	Pierpont Siding
Potomac Brick Co.	Washington, D. C.	Addison
Potomac River Clay Works	Takoma Park, D. C.	Alexandria
Potus Estate, E. H.	Chase City	Chase City
Powers Bros. & Maynard	Richmond	Richmond
Powhatan Clay Manufacturing Co.	Richmond	Clayville
Radford Brick Co.	Philadelphia, Pa.	Tiptop
Rea, B. A. (Formerly Jno. W. Legg)	Stevensburg	Stevensburg
Ready, W. J.	Manchester	Manchester and Henrico
Redford, N. C.	Richmond	Manchester
Reynolds, R. C. (Formerly T. G. Layfield)	Oldfield	Oldfield
Richardson & Son, R. H.	Hampton	Diascond
Richlands Brick Corporation	Norton	Richlands
Roanoke Brick Co. (Adams, Payne & Gleaves, Inc., Prop.)	Roanoke	Roanoke
Roanoke Clay Manufacturing Co.	Roanoke	Webster
Rosslyn Brick Co.	Washington, D. C.	Rosslyn
Rosslyn Clay Material Co., Inc.	Rosslyn	Rosslyn
Saint Paul Normal & Industrial School	Lawrenceville	Lawrenceville
Seale & Co., C. M.	Rose Hill	Lennie
Shrum Bros.	Dayton	Dayton and Harrisonburg
Southern Brick Co. (Formerly Geo. J. Fletcher)	Fredericksburg	Fredericksburg
Southern Clay Manufacturing Co.	Chattanooga, Tenn.	Chilhowie
Southern State Hospital	Marion	Marion
Southside Brick Co.	Fredericksburg	Fredericksburg
Standard Brick Co., Reed Bros. & Co., Props.	Portsmouth	Suffolk
Staunton Realty Corporation	Staunton	Staunton
Stonega Coke & Coal Co. (Formerly Keokee Coal & Coke Co.)	Keokee	Keokee
Stringfellow, S. P., Recvr., American Hygienic Fire Brick-Tile Fireproofing Co., Inc.	(Richmond	Richmond
Suffolk Clay Co.	Suffolk	Ladysmith
Sweet Briar Institute	Sweet Briar	Sweet Briar
Taliaferro, J. L.	Richmond	Richmond
Travis, Frank M.	New London	New London
Turner, Mrs. Agnes L.	Ferguson's Wharf	Ferguson's Wharf
Turner, W. R.	Petersburg	Ettrick
Updike, Eston	Charlottesville	Charlottesville
Updike & Bro., R. L.	Charlottesville	Charlottesville
Virginia Brick Co.	Washington, D. C.	Arlington
Virginia Brick Co.	Seven Mile Ford	Seven Mile Ford

OPERATOR	OFFICE	WORKS
Virginia Brick Co.....	Suffolk	Suffolk
Virginia Brick Works.....	Richmond	East Fulton
Virginia Clay & Material Co., Inc.....	Farmville or Philadelphia, Pa	Hawk
Virginia Railway Co. (Formerly Lantry Ballast Co.).....	Norfolk	Pembroke
Vulcan Fire Brick Co.....	Baltimore, Md	Wilmont
Walker Brick Co.....	Washington, D. C....	Arlington
Ward Brick Co.....	Galax	Galax
Ward & Cornett	Elk Creek	Elk Creek
Washington Brick & Terra Cotta Co.....	Washington, D. C....	Riverside Park
Watson Brick Corporation, John T.....	Danville	Danville
Waverly Brick Co., Inc.....	Petersburg	Waverly
West Bros. Brick Co.....	Washington, D. C....	Arlington
West End Brick Co.....	Suffolk	Suffolk
Wetherell, Geo. W.....	Blackstone	Blackstone
Whitfield Bros	Suffolk	Suffolk
Williamson, Chas. E.....	Petersburg	Petersburg
Williamson, Hedgecock & Fontaine, Inc....	Martinsville	Fontaine
Wine, J. W.....	Mt. Sidney	Mt. Sidney
Wood & Futrell.....	Emporia	Emporia
Young, Wm. J.....	Manassas	Manassas
Zirkle, W. H.....	Broadway	Broadway
POTTERY		
Adamant Porcelain Co., Ltd.....	Broadway	Broadway and Harrisonburg
Akron Smoking Pipe Co.....	Mogadore, Ohio	Pamplin City
Bell Bros	Strasburg	Strasburg
Powhatan Pipe Co.....	Michaux	Michaux
RAW CLAY		
Branch, John P.....	Richmond	City Point
Dickinson Fire Brick Co.....	Buena Vista	Buena Vista
Frazer Paint Co.....	Bedford City	Bedford City
McNicol, John A., Recvr., Blue Ridge Kao-lin Co.....	East Liverpool, Ohio...Oak Level, R. D. Edgewood	
Powhatan Clay Mfg. Co.....	Richmond	Clayville
Swineford, Howard	Richmond	Bermuda Hundred
Virginia Clay & Material Co.....	Farmville	Hawk
Warrell, N. J. & B. E.....	Sylvatus	Sylvatus

LIME AND CEMENT.

Lime and cement are obtained from limestone, which is described on pages 77 to 82, inclusive. Plants for their manufacture are scattered widely over western Virginia, where raw material, admirably adapted to the manufacture of lime and cement, occurs in great abundance. Plants for the burning of lime are found in most of the counties west of the Blue Ridge, while the manufacture of Portland cement is limited at present to two mills, one in Augusta County, the other at

Norfolk. Mills for the manufacture of natural cement are limited to Rockbridge and Botetourt counties. There was no reported production of natural cement in the State for the years 1909 and 1910.

LIME.

During recent years, lime-making in Virginia has been confined to the counties west of the Blue Ridge, where there are numerous plants engaged in the industry. There occur abundant limestones throughout this region admirably adapted to the making of lime. These range from very pure limestones to those high in magnesia. The former when burned or calcined yield "high limes" or "fat limes," while the latter produce "lean" or magnesian limes. Most of the lime made in Virginia belongs to the first class, and is especially valued by the builders and farmers.

The crystalline limestones of the Piedmont Plateau yield when calcined a good grade of lime. Formerly, numerous small kilns were operated within the limits of this region for the production of lime to supply only immediate local demands. In recent years, however, these have been abandoned, and at present no lime is burned from the Piedmont limestones.

The shell marls of the Coastal Plain region are dug and used locally, in the natural state, as fertilizer on the farming lands. These marls frequently form extensive deposits of considerable purity, and since they occur as loose incoherent material, and usually in a finely comminuted state, they can be easily dug and readily applied in the natural state to the soil.

The total production of lime in Virginia in 1909 was 166,695 short tons, valued at \$635,946, as compared with 107,209 short tons, valued at \$424,374 in 1908. This represents an increase of approximately 55.5 per cent in quantity (59,486 short tons) and 49.8 per cent in value (\$211,572). The average price per ton in 1909 was \$3.81 $\frac{1}{2}$ as against \$3.95 in 1908. This production was distributed over twelve counties and forty-nine producers. The counties producing lime in 1909 were Augusta, Botetourt, Frederick, Giles, Loudoun, Montgomery, Rockbridge, Rockingham, Russell, Shenandoah, Tazewell, and Warren.

The production of lime in Virginia during 1910 amounted to 141,257 short tons, valued at \$563,567. Compared with the figures for 1909, it will be seen that there was a decrease of 25,438 short tons in quantity and \$72,379 in value. There were forty-eight producers of lime in the State during 1910, and the production was distributed among the following 14 counties: Augusta, Botetourt, Frederick, Giles, Loudoun, Montgomery, Norfolk, Roanoke, Rockbridge, Rockingham, Russell, Shenandoah, Tazewell, and Warren.

There are given in the table below the production and value of lime in Virginia during 1909 and 1910, by counties.

Production and value of Lime in Virginia in 1909 and 1910, by counties.

County	1909		1910	
	Production Short tons	Value	Production Short tons	Value
Augusta	3,035	\$ 10,552	1,671	\$ 5,795
Botetourt	30,521	115,069	25,137	95,012
Frederick	29,668	102,500	28,323	106,258
Montgomery	13,370	69,708	(a)	(a)
Rockingham	4,652	16,258	4,548	16,829
Shenandoah	32,164	131,677	45,798	198,186
Other counties ^a	53,285	190,182	35,780	141,437
Total	166,695	\$635,946	141,257	\$563,567

^aIncludes during 1909, Giles, Loudoun, Rockbridge, Russell, Tazewell, and Warren; and during 1910 those of 1909 and the additional counties, Montgomery, Norfolk, and Roanoke.

In the table below is given the production of lime in Virginia in 1909 and 1910, by uses.

Production of Lime in Virginia, in 1909 and 1910, by uses, in short tons.

	1909		1910	
	Quantity	Value	Quantity	Value
Building lime	89,546	\$361,896	76,361	\$322,529
Hydrated lime	(a)	(a)	.....	.....
Paper mills	(b)	(b)	13,714	45,215
Fertilizer	57,606	205,896	33,766	118,419
Gas works .....	.....	.....	.....	.....
Tanneries	1,176	4,489	1,774	6,013
Chemical works	(b)	(b)	3,264	12,641
Dealers—uses not specified..	8,045	28,068	12,378	58,750
Other purposes	22	115	.....	.....
Miscellaneous	10,300	35,482	.....	.....
Total	166,695	\$635,946	141,257	\$563,567

^aOnly a small quantity of the lime produced in Virginia is hydrated.

^bIncluded under miscellaneous.

^cIncludes gas and chemical works.

LIST OF LIME OPERATORS

OPERATOR	OFFICE	KILN
Alleghany Lime Co., Inc.....	Christiansburg	Houchin Station
Andrews & Co., Inc., T. C.....	Norfolk	Norfolk
Beinkampen Lime Co.....	Radford	Radford
Blankenship, S. M.....	Deerfield	Deerfield
Bristol Lime & Stone Co., Inc.....	Bristol, Va.-Tenn	Benhams
Church, E. W.....	Staunton	Craigsville
Conner, I. N.....	Vaucluse Station	Vaucluse Station
Cooper, I. C.....	Hinton	Hinton
Coverston, Eli and Samuel.....	Pelton	Seven Fountains
Crann, I. N.....	Bridgewater	Mossy Creek
Davis, C. W.....	Blacksburg	Blacksburg
Davison, Louis F.....	Harrisonburg	Harrisonburg
Dillon's Sons, E.....	Indian Rock	Indian Rock
Eagle Rock Lime Co.....	Richmond	Eagle Rock
Eureka Lime Co.....	Vicar Switch	Vicar Switch
Evers, D. L.....	Bridgewater	Mossy Creek
Fellsworth Lime Works.....	Staunton	Staunton
Fox, J. W.....	Ottobine	Ottobine
Grove Lime Co., M. J.....	Limekiln, Md	Stephens City
Haldeman, H. F.....	Churchville	Churchville

OPERATOR	OFFICE	KILN
Harris, J. A.	Stuarts Draft	Stuarts Draft
Herbaugh, Robert L.	Zepp	Zepp
Hoag Co., William N.	Strasburg or New York, Strasburg N. Y.	
Hogshead, Thos. K.	Sangerville	Sangerville
Hogshead, Charles A.	Mossy Creek	Mossy Creek
Huggins & Co., H. H.	Roanoke	Roanoke
Kiracofe, C. S.	Bridgewater	Bridgewater
Kirk, John Y.	West Norfolk	West Norfolk
Leesburg Lime Co., Inc.	Leesburg	Leesburg
Limonet Lime Co.	Limonet	Limonet
Linville Lime Co.	Linville	Linville
Luray Lime Co.	Eura	Luray
McIlwee, C E.	Zepp	Zepp
McKimmy, A. G.	Luckets	Luckets
Michael, J. W.	Springcreek	Sangerville
Miller, E. X.	Bridgewater	Bridgewater
Moore Lime Co.	Richmond	Eagle Rock
Natural Bridge Lime Co.	Glasgow	Sherwood
New River Lime Co.	Ripplemead	Ripplemead
Oak Ridge Lime Firm.	Mt. Solon	Mt. Solon
Orndorff, M. M.	Oranda	Oranda
Oyler, George V.	Winchester	Winchester
Powhatan Lime Co.	Strasburg	Strasburg
Pullins, A. C.	Mount Sidney	Mount Sidney
Rawley, N. B.	Churchville	Churchville
Riverton Lime Co.	Riverton	Riverton
Roanoke Stone & Lime Co., Inc.	Roanoke	Lithia
Rockbridge Lime & Stone Co.	Lexington	Lexington
Rockdale Lime Co.	Toms Brook	Toms Brook
Rusmiselle, J. A.	Mt. Solon	Mt. Solon
Sanger, C. D. and M. G.	Sangerville	Sangerville
Senger, D. M.	Mt. Solon	Mt. Solon
Shenandoah Lime Co.	Strasburg Jet	Strasburg Jet.
Shenandoah Lime & Stone Co.	Strasburg	Strasburg
Shinault, C. W.	Deerfield	Deerfield
Shoop, Withers Co.	Suffolk	Suffolk
Snarr, G. H.	Wheatfield	Wheatfield
Stuart Land & Cattle Co.	Elk Garden	Elk Garden
Tazewell White Lime Works.	North Tazewell	North Tazewell
Thompson, T. W.	Hinton	Hinton
Wheelbarger-Rumsey Lime Cor.	Bridgewater	Bridgewater
Whitesell, D. E.	Stuarts Draft	Stuarts Draft
Wine & Wright.	Spring Creek	Spring Creek
Wingate & McGhee.	Roanoke	Roanoke
Woodstock Lime Co., Inc.	Woodstock	Woodstock

CEMENT.

Although the cement industry may be said to be in its infancy in Virginia, yet the manufacture of this important economic product has been carried on for many years at one locality, and for a less time at another. Natural cement has been burned at Balcony Falls for over

a half century. The demand for a cheap and trustworthy cement for use in the construction of masonry, locks, and walls on the James River canal, led to the discovery of the hydraulic properties of the rock used at this plant. Since that time a natural cement has been manufactured at this locality almost continuously, the James River Cement Company operating the plant at present. The rock used is a blue, argillaceous limestone of Lower Cambrian age, with an average thickness of 12 feet.

There are only two plants for the manufacture of Portland cement in Virginia in operation at present, namely, that of the Virginia Portland Cement Company at Fordwick, Augusta County, and that of the Norfolk Portland Cement Corporation at Norfolk. The Fordwick plant has a capacity of 1,250,000 barrels, and is selling the Old Dominion cement in the North as well as in the South. The materials used by this plant in the manufacture of Old Dominion cement are Lewistown limestone and shale. The Norfolk plant is the first plant built in the South to manufacture Portland cement from shell marl as the principal calcareous material instead of the hard rock—limestone. The marl and clay deposits used by this plant are located on branches of James River near Smithfield and Chuckatuck.

Two additional plants of large capacity have been granted charters for the manufacture of Portland cement in Tidewater (Coastal Plain) Virginia. These are the Jamestown Portland Cement Company's plant to be located at Yorktown, and the Colonial Portland Cement Company's plant to be located near Grove. The raw materials to be used by these plants for the manufacture of Portland cement will be the Miocene marls and clays of the immediate area.

There being only two plants in Virginia producing Portland cement in 1910, the figures of production are combined with those of another subject in order to avoid disclosing individual operations.

Virginia possesses an abundance of raw materials from which cement can be made—an economic resource which will prove of great value. The Appalachian Valley and the various mountains and valleys westward, an area of 350 or more miles long and averaging 50 miles in width, contains limestones and shales equal in value and abundance to those of any other region. The State Geological Survey has issued a

valuable report^a on the Cement Materials west of the Blue Ridge. This report is based on several seasons of careful investigations in the field, and contains an unusually large number of chemical analyses made of the limestones and shales from all parts of the region.

Four prominent sources of cement material obtain in western Virginia. Named in geologic order, these are:

4. Greenbrier (Mississippian) limestone.
3. Lewistown (Helderbergian) limestone.
2. Ordovician (Trenton, etc.) limestones and shales.
1. Cambrian—impure limestone and shale.

Of these, the limestones and shales of Ordovician age are the most promising on account of their abundance, widespread distribution, and usually favorable chemical composition. The Lewistown limestone is now used in the manufacture of Portland cement at Craigsville, Augusta County, and the Greenbrier limestone will probably become an important source of cement material in southwestern Virginia.

The most important cement materials of western Virginia are found in the pure and argillaceous limestones of Cambrian and Ordovician age, and in the calcareous and argillaceous phases of the Ordovician shales. These shales and limestones have a wider distribution and are usually more accessible than other cement rock horizons of the State, such as the Lewistown of Helderbergian age, and the Mississippian or Subcarboniferous (Greenbrier) limestone. In general the entire Valley of Virginia is underlain by the Cambrian and Ordovician limestones, while the shales usually outcrop along the base of the mountains bounding it. In a similar manner, many of the valleys west of the Great Valley show these limestones and shales, higher formations occurring on the separate ridges.

Three classes or groups of hydraulic cements^b are recognized, and materials for their manufacture occur in Virginia. Named in the order of their importance, these are: (1) Portland cement, (2) Natural cement, and (3) Puzzolan cement.

^aBassler, R. S., Virginia Geological Survey, Bulletin No. II-A, 1909.

^bIbid., 1909, pp. 5-32.

Eckel, E. C., *Cements, Limes, and Plasters: Their Materials, Manufacture, and Properties*. John Wiley and Sons, New York, 1907.

In the manufacture of Portland cement, a finely ground mixture containing lime, silica, alumina, and iron oxide, in exactly determined proportions, is burnt at a temperature approaching 3,000° F. This burning produces a semi-fused mass called "clinker" which, as a last step in the process of manufacture, must be finely ground. The theoretical mixture employed for burning consists of 75 per cent calcium carbonate, 20 per cent iron, alumina, and silica, and 5 per cent allowed for magnesium carbonate and other substances. This ideal composition is seldom realized in nature and, as a rule, an artificial combination is made by mixing limestone or marl with clay or shale. In this case, one part of the clayey materials is generally added to three parts of pure limestone.

The raw material from which natural cement is made is an argillaceous limestone carrying from 13 to 35 per cent of clayey material, of which about 10 to 22 per cent is silica, while alumina and iron oxide together may vary from 4 to 16 per cent. Unlike Portland cement rock, the percentage of magnesium carbonate may run high, the reason for this being that in natural cements the magnesia and lime are regarded as interchangeable. The hydraulic properties do not depend upon the percentage of lime but upon the clayey materials, which are the important factors to consider in the rock analysis.

Limestones having a composition within the limits just indicated are more or less abundant at several horizons in western Virginia, but probably the only one which will meet all the requirements and prove of economic importance is the argillaceous magnesian limestone of the lower part of the Shenandoah group. This rock, although often very similar in lithologic characters to the dolomitic limestone found higher in the Shenandoah group, can be recognized as containing argillaceous matter by the clayey odor given forth when breathed upon.

These limestones (Sherwood) and shales (Buena Vista) form the source of the rock used by the James River Cement Works, near Balcony Falls, Virginia, for making natural cement. These strata are found at various points along the eastern side of the Appalachian Valley in Virginia, so that a considerable supply of the necessary materials should be available.

The erection and operation of Portland cement plants, such as are now proposed in Tidewater Virginia, will have a stimulating influence on the entire industrial activity of the State.

LIST OF CEMENT OPERATORS

OPERATOR	OFFICE	PLANT
James River Cement Co.....	Balcony Falls	Balcony Falls
Norfolk Portland Cement Corporation.....	Philadelphia, Pa	Norfolk
Virginia Portland Cement Co.....	New York, N. Y.....	Fordwick

SAND AND GRAVEL.

The production of sand and gravel in Virginia during 1909 amounted to 847,476 short tons, valued at \$281,177, as compared with 449,234 short tons, valued at \$119,095, in 1908, which represents an increase of 398,242 short tons, or 88.67 per cent, in quantity, and \$162,082, or 73.47 per cent, in value. The 1910 production was 764,321 short tons, valued at \$215,416.

These figures do not represent the total production of sand and gravel in Virginia, as large quantities are produced and utilized each year in the manufacture of brick, and in railway, highway, and sidewalk construction, etc., of which no record of the quantity used is kept and no returns are made to the office of the State Survey. Much the largest proportion of sand used in the State, for which returns are made, is for building and molding. In 1909, there were 33 producers of sand and gravel operating in 20 counties, and in 1910, 33 producers operating in 19 counties. The production of sand in Virginia during 1910, by counties, was as follows: Elizabeth City, 56,272 short tons, valued at \$31,229; Giles, 19,400 short tons, valued at \$11,590; Henrico, 29,391 short tons, valued at \$24,947; Roanoke, 6,500 short tons, valued at \$2,625; Rockingham, 5,005 short tons, valued at \$2,381; other counties,^a 200,552 short tons, valued at \$54,853.

The following table shows the details of the industry, and the comparative quantities and values from 1905 to 1910, inclusive.

^aIncludes Alleghany, Alexandria, Amherst, Carroll, Campbell, Charles City, Norfolk, Princess Anne, Prince George, Pulaski, Scott, Shenandoah, Washington, and Wise.

Production of Sand and Gravel in Virginia, 1905-1910, by uses, in short tons.

	1905		1906		1907	
	Quantity	Value	Quantity	Value	Quantity	Value
Sand—						
Glass .....	.....	.....	.....	.....	1,246	\$ 4,535
Molding	61,246	\$ 37,899	26,654	\$ 15,466	50,627	30,377
Building	244,572	96,248	272,396	91,265	158,715	67,160
Fire	810	405	1,000	500	.....	.....
Engine	4,775	3,580	4,370	1,970	10,239	4,603
Furnace	4,212	2,665	21,376	8,028	10,059	4,227
Other	250	330	8,602	4,072	24,334	9,958
Gravel	35,250	13,453	780	650	13,002	2,952
Total	351,115	\$154,580	385,178	\$121,951	268,222	\$123,812

	1908		1909		1910	
	Quantity	Value	Quantity	Value	Quantity	Value
Sand—						
Glass .....	.....	.....	.....	.....	700	\$ 450
Molding	47,888	\$ 22,568	25,480	\$ 17,241	35,517	24,954
Building	139,742	61,378	368,744	125,208	251,170	88,340
Fire .....	.....	.....	.....	.....	.....	.....
Engine	6,651	2,860	3,594	1,585	1,900	1,165
Furnace	11,295	5,500	9,740	4,563	5,339	2,088
Other ^a	670	325	47,631	8,149	22,494	10,628
Gravel	242,988	26,464	392,287	124,431	447,201	87,791
Total	449,234	\$119,095	847,476	\$281,177	764,321	\$215,416

^aIncludes for 1910 polishing and filtration sand.

LIST OF SAND AND GRAVEL OPERATORS

OPERATOR	OFFICE	BED OR PIT
Adair, James	Lurich	Lurich
American Locomotive Co.	Richmond	Richmond
Appomattox Iron Works	Petersburg	Petersburg
Bickford Sand & Gravel Co., Inc.	Hampton	Hampton
Bolton, John T.	Norfolk	Hampton
Botto Sand Co., J. L.	Richmond	Richmond
Bromilaw Brick Co.	Alexandria	Alexandria
Calhoun & Bro., James W.	North River	North River
Carter, Mrs. M. E.	Buddle	Pulaski City
Catawba Valley Ry. & Mng. Co.	Salem	Salem
Cavedo, W. L.	Richmond	Richmond
Chesapeake & Ohio Railway Co.	Basic City	Basic City
Cheshire & Sons, J. W.	Martinsville	Martinsville
Christian, J. H.	Providence Forge	Providence Forge
Clinedinst, Jno. S.	Edinburgh	Edinburgh
Columbia Granite & Dredging Co.	Washington, D. C.	Potomac River
Cooper Glass & Silica Co.	Salem	Salem
Cowardin, S. P.	Richmond	Richmond
Cuddy, W. T.	Lurich	Lurich
Curlis, H. C.	Holdcroft	Holdcroft
Darst, Jno. C.	Bluff City	Bluff City
Derbyshire, Mrs. M. J.	Richmond	Richmond
Dills, M. C.	Bluff City	Pearisburg
Eanes, A. W.	Roanoke	Roanoke
French & Bro., J. E.	Curve	Curve
French, K. S.	Narrows	Narrows
Gibboney Sand Bar Co., Inc.	Berton	Berton
Gill, E. F.	Providence Forge	Providence Forge
Gill & Bro., J. M.	Providence Forge	Providence Forge
Gochenour, J. J.	Maurertown	Maurertown
Goddin Supply Co., Inc.	Richmond	Richmond
Harbaugh, Mrs. S. I.	Richmond (Fairmont)	Richmond
Hoxall, L.	Providence Forge	Providence Forge
Hunter Farmers Friend Plow Works, The Charles E.	Fredericksburg	Fredericksburg
International Sand & Material Co.	Norfolk	Norfolk
Ivanhoe Furnace Co.	Ivanhoe	Ivanhoe
Jackson, D. E.	Galts Mill	James River
Johnston, J. Raleigh	Bluff City	Bluff City
Laughon & Co., B.	Pulaski	Laughon Siding
Lillie, Geo. W.	Richmond	Richmond
Linkous, R. T.	Narrows	Narrows
Lowmoor Iron Company of Virginia	Lowmoor	Lowmoor
Maupin, R. W.	Waynesboro	Waynesboro
Monger, Jno. H.	North River	Harrisonburg
Myers, J.	Roanoke	Roanoke
National Mfg. Co., Inc.	Lynchburg	Lynchburg
Norfolk Railway & Light Co.	Norfolk	Norfolk
Norfolk & Southern Railway Co.	Norfolk	Cape Henry
Perkinson & Finn.	Petersburg	Petersburg
Port Republic Foundry.	Port Republic	Port Republic
Presque Gravel Co.	Norfolk	<div style="display: flex; align-items: center;"> James River Dutch Gap Ocher Petersburg </div>

OPERATOR	OFFICE	BED OR PIT
Pure Silex Co.....	Scottsville	Scottsville
Quarles, A. G.....	Richmond	Richmond
Radford, Mrs. Emma.....	Richmond	Richmond
Richardson, R. E.....	Providence Forge	Providence Forge
Richmond, Fredericksburg & Potomac Rail-way Co.	Richmond	(Bowling Green Fredericksburg)
Rodgers, James M.....	James River	James River
Rogers, E.....	Ivanhoe	Ivanhoe
Sellers, Dr. J. S.....	Weyers Cave	Weyers Cave
Shepherd, Larkin.....	Appalachia	Appalachia
Slaughter & Griffin.....	Fredericksburg	Fredericksburg
Umwstader, J. M.....	Norfolk	Norfolk
Water Works Supply Corporation.....	Norfolk	Norfolk
Webb J. H.....	Roanoke	Glad Creek
Wills, T. L.....	Lynchburg	Lynchburg

SAND-LIME BRICK.

The term sand-lime brick is used "to cover all brick made by mixing sand or gravel with a relatively small percentage of slaked lime, pressing the mixture into form in a brick mold, and drying and hardening the product either by sun heat or artificial methods."^a

The manufacture of sand-lime brick in Virginia commenced only a few years ago. The total number of sand-lime brick produced in 1908 was 6,181,000 brick, valued at \$36,934, of which 6,123,000 were common brick valued at \$36,184. On account of there being only two producers of sand-lime brick in the State during 1909, the figures are given under "Other products" in the table on page 5, in order to avoid disclosing individual production. The 1910 production of sand-lime brick in Virginia is included under "Other products" in the table on page 6.

LIST OF SAND-LIME BRICK OPERATORS

OPERATOR	OFFICE	WORKS
Cape Henry Granite Brick Corporation	East Radford	East Radford
New River Sandstone Brick Co.....	East Radford	East Radford
Norton Silica Brick Co.....	Norton	Norton
Old Dominion Granite Brick Co.....	Cape Charles	Cape Charles
Virginia Sand-Lime Brick Co.....	Norfolk	Norfolk

^aEckel, E. C. Cements, Limes, and Plasters: Their Materials, Manufacture, and Properties. John Wiley and Sons, New York, 1907.

STONE.

The production of stone has been an important industry in the State for many years, and the product of some varieties, especially granite, has been used in many notable structures. The rocks of Virginia include a large variety and abundance of excellent stone suitable for building, decorative, and other purposes. These have wide distribution over the Crystalline and Mountain provinces, comprising in the former, granite, gneiss, and schist, trappean rocks, in part known to the trade as black granites, slate, quartzite and sandstone, limestone and marble; and in the latter, sandstone, limestone, and marble.

The stone industry is the fourth in importance among those based upon the mineral wealth of the State, being surpassed only by the coal, clay products, and iron ores. The value of the annual production of stone in Virginia from 1900 to 1910, inclusive, is given in the accompanying table.

Value of the annual production of Stone in Virginia from 1900 to 1910, inclusive.

Year	Granite Value	Sandstone Value	Slate Value	Limestone Value	Total Value
1900	\$211,080	\$ 6,000	\$190,211	\$403,318	\$ 810,609
1901	275,701	5,303	178,979	986,177	1,416,160
1902	282,046	2,500	160,951	534,113	979,610
1903	299,335	4,471	115,356	569,205	988,367
1904	510,788	13,522	130,208	442,978	1,097,496
1905	452,390	2,000	146,786	212,660	813,836
1906	340,900	5,100	172,857	260,343	779,200
1907	398,426	(a)	173,670	362,062	935,158
1908	321,530	2,600	194,356	280,542	799,028
1909	488,250	28,574	180,775	342,656	1,040,255
1910	503,106	25,080	148,721	471,903	1,148,810

aSmall value included with West Virginia.

The total value of the different kinds of stone quarried for the period of years for which statistics are given, shows that the quarrying of limestone is the largest industry in stone, with granite next, and slate third. For the past several years granite has been of first importance, although the difference in the annual value of its production

and that of limestone is very small. The variation in limestone production is controlled in large part by the blast furnace conditions where it is used as a flux. The production of sandstone for the period represented in the table is relatively unimportant.

The value of the total production of stone in the State during 1909 was \$1,040,255, while the value for 1910 was \$1,148,810.

GRANITE.

Granites, including the foliated type gneisses, have very wide distribution throughout the Virginia Piedmont region, constituting one of the dominant rock types. The general excellence of the Virginia granites as a building and ornamental stone has long been established in the commercial world. There is not a county within the limits of the Piedmont region that does not contain some granite, but the quarrying industry has thus far been limited to less than half a dozen counties. The principal producing areas of massive granites are distributed along the eastern border of the Piedmont Plateau. They include (1) the Petersburg area, (2) the Richmond area, and (3) the Fredericksburg area. The principal counties composing these areas are Dinwiddie, Chesterfield, Henrico, and Spotsylvania. A small amount of granite has been quarried in a number of other counties within the limits of the Piedmont to supply strictly a local demand.

The granites of the State are chiefly granular aggregates of the minerals quartz, feldspar, and mica. Hornblende and epidote are important minerals in the granites of a few localities in the State, the latter being conspicuous in the variety of granite known as unakite, which is found in Madison, Page, and Grayson counties. Based then on mineral composition, we have the following varieties of Virginia granite: (1) Biotite granite, under which vastly the majority of the granites of the State belong; (2) muscovite granite; (3) hornblende-biotite granite; and (4) epidote granite.

The chemical composition of the granites in the Richmond, Petersburg, and Fredericksburg areas is shown in the table of analyses on page 73.

Analyses of Virginia Granites.

(W.M. M. THORNTON, JR., Analyst.)

Constitutents	I	II	III	IV	V	VI	VII	VIII
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Silica (SiO_2)	72.27	71.51	71.19	70.83	69.48	69.44	69.29	68.45
Alumina (Al_2O_3).....	14.30	13.82	14.01	12.70	13.95	15.46	14.07	10.00
Ferric oxide (Fe_2O_3).....	1.16	1.76	1.66	2.67	2.82	1.31	2.59	5.71
Ferrous oxide (FeO).....	0.97	1.20	1.29	1.36	1.70	1.43	2.03	2.59
Magnesia (MgO)	0.70	0.80	0.44	0.53	1.10	1.01	1.32	3.26
Lime (CaO)	1.56	1.79	2.04	1.88	2.81	2.11	2.76	6.20
Soda (Na_2O)	3.46	3.64	3.56	3.49	3.65	3.97	2.89	1.98
Potash (K_2O)	5.00	4.63	4.45	4.83	3.45	4.25	2.87	1.18
Water (H_2O) -110° C.....	0.04	0.17	0.04	0.07	0.04	0.07	0.06	0.18
Water (H_2O) +110° C.....	0.25	0.31	0.33	0.34	0.50	0.29	0.37	0.62
Titanium oxide (TiO_2)....	0.31	0.33	0.35	0.41	0.47	0.48	0.50	0.20
Manganese oxide (MnO)....	trace	0.03	0.02	0.03	0.03	0.03	0.08	0.05
Carbon dioxide (CO_2).....	0.21	trace	trace	trace	trace	trace	trace	trace
Phosphoric acid (P_2O_5)....	0.02	0.30	0.34	0.33	0.49	0.22	0.26	0.25
Total	100.25	100.29	99.72	99.47	100.49	100.07	99.09	100.67

- I. Medium-textured and medium gray, biotite granite. Westham granite quarries, 4.5 miles west of Richmond, Chesterfield County.
- II. Medium-textured and medium gray, biotite granite. Lassiter and Petersburg Granite Co.'s quarries, Petersburg, Dinwiddie County.
- III. Fine-grained, dark blue-gray, biotite granite, McGowan, Netherwood, and Donald quarries, Chesterfield County, and Mitchell and Copeland quarry, Henrico County, near Richmond.
- IV. Medium coarse-textured and medium gray, biotite granite. Netherwood, State (Old Dominion), Granite Development Co., Krimm and Middendorf quarries, Chesterfield County, near Richmond.
- V. Fine-grained, dark blue-gray, biotite granite. Cartwright and Davis quarries, near Fredericksburg, Spotsylvania County.
- VI. Medium-textured and medium gray, biotite granite. McIntosh quarry, Chesterfield County, 5 miles west of Richmond.
- VII. Medium coarse-textured, gray, biotite granite-gneiss. Middendorf (Belt Line Railway) quarry, near Manchester, Chesterfield County.
- VIII. Medium coarse-textured, gray, biotite granite-gneiss. Cartwright and Davis quarries, near Fredericksburg, Spotsylvania County.

The Richmond area is the principal granite-producing area in the State. Not less than 20 quarries have been worked within the limits of the area, some of which are very extensive, being worked to a depth of nearly 200 feet. Two grades of granite are quarried, one a fine-grained, dark blue-gray rock, extensively used as monument stock, the

other a coarser grained and lighter colored gray rock admirably suited for building purposes. Both are homogeneous even-granular granites, possessing good working qualities. The fine-grained, dark blue-gray granite is susceptible of a high and permanent polish, and is a superior monumental stone.

Under the general head of granite are included in the trade such crystalline rocks as syenite, diorite, gabbro, and diabase, and the banded rocks known as gneiss and schist.

The production of granite during 1909 was valued at \$488,250, as against \$321,530 in 1908, a gain in value of \$166,720, or nearly 52 per cent. Twelve counties contributed to this production, namely, Alexandria, Amherst, Campbell, Chesterfield, Dinwiddie, Fairfax, Goochland, Greenesville, Henrico, Pittsylvania, Prince Edward, and Stafford. The uses made of the stone and the value of each are given in the table below. The 1910 production of granite in Virginia was valued at \$503,106.

There are given in the tables below the value and uses of the granite and gneiss quarried in Virginia during the years 1900 to 1910, inclusive.

Value of Granite produced in Virginia, 1900-1910, by uses.

Use	1900	1901	1902
Sold in the rough. { Building Monumental } Other }.....	\$ 12,000 8,300 230	\$ 40,763 45,737 52,404	\$ 21,158 28,840 51,612
Dressed for building.....	55,296	17,253	14,845
Dressed for monumental work.....	21,461	8,810	29,796
Made into paving blocks.....	16,605	7,977	
Curbing	8,810		
Flagging			
Rubble			26,255
Riprap	15,833	43,029	17,215
Crushed stone. { Road-making Railroad ballast } Concrete }.....	38,850	9,850 7,841 42,317	6,133 25,554 46,588
Other			1,000
Total	\$211,080	\$275,701	\$282,046

Value of Granite produced in Virginia, 1900-1910, by uses.—Continued.

1903	1904	1905	1906	1907	1908	1909	1910
\$ 26,345	\$ 33,613	\$ 31,224	\$ 18,158	\$ 19,350	\$ 26,769	\$ 24,965	\$ 31,841
13,440	17,320	10,415	15,804	8,039	12,664	1,966	3,771
.....	.....	.....	200	.....	1,075	.....	2,375
14,740	48,452	28,950	.....	13,275	4,000	17,750	14,750
43,845	55,608	37,180	16,936	9,787	29,803	9,449	6,300
28,034	30,966	19,220	29,536	18,072	10,173	18,053	28,596
4,582	33,324	8,948	14,339	6,000	6,180	29,100	57,511
5,485	3,516	2,550	1,216	.....	.....	990	1,565
28,449	40,524	28,961	28,477	16,350	18,270	33,321	38,792
22,410	7,630	27,236	31,790	28,852	16,336	1,386	6,989
31,785	12,940	21,175	34,981	59,987	21,670	74,054	40,691
17,400	61,352	69,360	64,386	50,804	92,895	125,704	111,811
60,820	165,043	166,364	85,077	167,960	81,745	147,112	156,894
2,000	500	807	.....	.....	.....	4,400	1,220
\$299,335	\$510,788	\$452,390	\$340,900	\$398,426	\$321,530	\$488,250	\$503,106

In the table below is given the number of granite paving blocks produced in Virginia, by years, from 1904 to 1910, inclusive.

Number and value of Granite Paving Blocks produced in Virginia, 1904-1910.

Year	Number	Value	Average Value per 1,000
1904	1,032,200	\$30,966	\$30.00
1905	913,440	19,220	21.05
1906	1,385,000	29,536	21.32
1907	685,100	18,072	26.38
1908	252,910	10,173	40.22
1909	853,300	18,053	21.16
1910	680,602	28,596	42.02

LIST OF GRANITE OPERATORS

OPERATOR	OFFICE	QUARRY
American Stone Co., Inc.	Richmond	Boscobel
Andrews & Co., J. W.	Petersburg	Petersburg
Bedford, A. C.	Richmond	Butterworth
Belmont Traprock Co., Inc.	Belmont Park	Belmont Park
Brennan Construction Co. (Gneiss)	Washington, D. C.	Chain Bridge
Brown, J. Henry	Richmond	Dunbarton Station
Butterworth, R.	Butterworth	Pride
Cartwright & Davis	Fredericksburg	Fredericksburg
Casey, John B.	Lynchburg	Lynchburg
Columbia Granite & Dredging Co.	Washington, D. C.	Washington, D. C.
Consolidated Quarry Co.	Washington, D. C.	Occoquan (near)
Cranford Paving Co. (Gneiss)	Washington, D. C.	Washington, D. C.
Danville, City of	Danville	Danville
Echols & Co., J. M.	Lynchburg	Lynchburg
Ford, J. R.	Lynchburg	Lynchburg
Forge Granite & Lumber Co.	Falmouth	Falmouth (near)
Fountain Creek Granite Co.	Norfolk	Hitchcock
Fredericksburg Power Co.	Fredericksburg	Fredericksburg
Hall, Wm. W.	Lynchburg	Lynchburg
Harris, H. J.	Richmond	Boscobel (Harris Siding)
Holland, H. S.	Richmond	Buffalo Station
Island Granite Co., Inc.	Richmond	Richmond
James River Granite Co.	Richmond	Richmond (Holland Siding)
Jones, Harvey	Lynchburg	Lynchburg
Lane Bros. Co.	Alta Vista	Alta Vista
Lee Stone Co.	Lee	Lee
Lennox, John	Rio Vista	Rio Vista
Logan, A.	Lynchburg, R.F.D. No. 3	Lynchburg
Lone Jack Stone Co. (Gneiss)	Lynchburg	Lynchburg
McClay Granite Co., John A.	Richmond	Richmond
McGowan, John	Richmond	Manchester
McGranaghan, P.	Granite	Granite
McIntosh, Hugh (Chesterfield Granite Works)	Granite	Granite
Moncure, Pettitt & Moncure	East Falls Church (or Alexandria C. H.)	Falls Church
Morris & Lipscomb	Roanoke	Goodview
Nelson Stone Co., Taylor Gleaves	Lynchburg	Faber
Netherwood, Albin	Richmond	Richmond
Norfolk County Road Board	Norfolk	Emporia
Occoquan Stone & Lumber Co.	Occoquan	Occoquan
Old Dominion Iron & Nail Works	Richmond	Belle Isle
Petersburg Granite Co.	Baltimore, Md	Petersburg
Rockfish Ballast Co.	Baltimore, Md	Rockfish
Slocombe, W. A.	Farmville	Farmville
Slocombe & Hall	Lynchburg	Lynchburg
Smith & Co., Inc., I. J.	Richmond	Richmond
Southern Quarry Co.	Washington	Rockfish
Sunnyside Granite Co., Inc.	Richmond, R.F.D. No. 2	(Dunbarton Station)
Virginia Granite Co.	Richmond	Dunbarton Station
Virginia Quarrying Corporation	Norfolk	Manchester
Virginia State Farm	Lassiter	Lassiter
Wakefield Granite Quarries	Petersburg	Petersburg
Wray, A. J.	Richmond	Granite

MARBLE.

Marbles are found in the Mountain province west of the Blue Ridge and in the Piedmont province to the east, but there has been but slight attempt to develop them, owing chiefly to a lack of definite knowledge of their extent and quality. Bands occur in some of the limestones of the Mountain province, especially in the Shenandoah and Chickamauga formations, of a color and texture which adapt them to ornamental purposes. These show a variety of color and texture. White, gray, red, and black colors are found. These marbles have not received the attention which they apparently merit in places, and the developments thus far are slight.

Onyx marbles are fairly abundant in the limestone caves and caverns of the Valley region, but it is probable that these will rank as "uniques" rather than objects of commercial value. Large deposits of onyx marbles are found near Bridgewater in Rockingham County, but they have not been investigated and very little is known of their quality.

Marbles of excellent quality occur in the vicinity of Goose Creek, Loudoun County. Samples of the white marble are not excelled for purity of color, fineness of grain, and general excellence, by that of any other marble in the United States. At Goose Creek, the marble bed is about 52 feet thick and has been worked to a considerable depth. The varieties shown are chiefly white, but there occur, also, banded blue and white, serpentinized white and green, pink and white, and green and white. These beds are pure, and the stone is of great beauty and takes a good polish. The lack of transporation facilities has thus far prevented extensive quarrying.

Undeveloped areas of marbles are known in Grayson, Campbell, Nelson, and Pittsylvania counties. Openings were made in some of these many years ago and the stone burned into lime.

There has been no production of marble in Virginia for several years.

LIMESTONE.

Limestone has its greatest distribution in the region west of the Blue Ridge where it forms one of the dominant rock types. It has had only a limited use for building purposes, but has been extensively

quarried for use as a furnace flux, for lime-making in building and agriculture, for road metal and ballast, for concrete, and for the manufacture of Portland and natural cements. Four prominent sources of limestone obtain in this region, which, named in geologic order, are:

4. Greenbrier (Mississippian) limestone.
3. Lewistown (Helderbergian) limestone.
2. Ordovician (Trenton, etc.) limestone.
1. Cambrian limestone.

Of these four principal divisions of limestones, the Cambrian and Ordovician limestones constitute the Shenandoah (Valley) limestone group, which is the most persistent limestone group in the State. It is the underlying or basement rock of the Great Valley (Shenandoah) of Virginia. The most important and only limestone which has been used in buildings is the Shenandoah limestone of the Great Valley. In its normal development, it is probably not less than 3,500 feet thick and in places it is much thicker. It has a wide range in composition and is divisible into several different members. The most important member of the Shenandoah limestone for building stone is the Natural Bridge limestone, which is usually a heavy-bedded, dark blue to gray magnesian limestone, frequently dolomitic. Quarries have been opened in it, in many places through the Valley region, and the stone used locally for building purposes.

The Lewistown and Greenbrier limestones have not been used for building purposes, but each has been quarried in places, especially the Lewistown, and used for fluxing the iron ores at the blast furnaces.

The value of limestone produced in the State during 1909 was \$342,656, as compared with \$280,542 in 1908. This represents a gain of \$62,114, or slightly over 22 per cent, in value. This increase in production was due chiefly to an increased production of limestone for use as railroad ballast and fluxing purposes. There were 32 producers of limestone operating in fourteen counties of the State, as against 30 producers in 1908. There is given below in tabular form the value of limestone produced in Virginia in 1909, by counties.

Value of Limestone produced in Virginia in 1909, by counties.

County	Value
Augusta	\$ 5,081
Botetourt	59,695
Roanoke	13,511
Rockbridge	37,281
Other counties ^a	227,088
Total	\$342,656

^aIncludes Alleghany, Giles, Lee, Loudoun, Rockingham, Russell, Shenandoah, Tazewell, Washington, and Wythe.

The production of limestone in Virginia during 1910 was valued at \$471,903, which represents an increase in value over the 1909 production of \$29,247.

There were 37 producers of limestone in the State during 1910, operating in the following 15 counties: Alleghany, Augusta, Botetourt, Giles, Loudoun, Pulaski, Roanoke, Rockbridge, Shenandoah, Smyth, Tazewell, Warren, Washington, Wise, and Wythe.

The production of limestone in Virginia from 1902 to 1910, inclusive, and the uses for which it was quarried are given in the table below:

Production of Limestone in Virginia from 1902 to 1910, by uses.

	1902	1903	1904	1905	1906
Rough building	\$ 41,355	\$ 5,325	\$ 8,800	\$ 5,390	\$ 3,448
Dressed building			360	700	1,680
Paving					275
Curbing					
Flagging					
Rubble			168		
Riprap		22		120	323
Crushed stone:					
Road making		300	210	5,254	160
Railroad ballast	7,875	16,205	32,371	9,333	16,050
Concrete	11,580	9,238	5,668	11,187	18,700
Flux	220,001	199,989	117,882	180,676	219,707
Unspecified	11,318	1,665			
Total	\$534,113	\$569,205	\$442,978	\$212,660	\$260,343

Production of Limestone in Virginia from 1902 to 1910, by uses.—
Continued.

	1907	1908	1909	1910
Rough building	\$ 3,170	\$ 1,870	\$ 715	\$ 125
Dressed building	1,130	2,950	129	.....
Paving	500	.....	15	45
Curbing .....	.....	79	.....	750
Flagging .....	.....	110	7	.....
Rubble .....	.....	.....	3,000	3,188
Riprap .....	.....	3,377	.....	1,805
Crushed stone:				
Road making	37,000	30,159	31,076	20,056
Railroad ballast	12,269	45,541	84,883	108,129
Concrete	32,326	26,604	8,068	36,849
Flux	275,517	169,847	213,444	294,668
Unspecified	150	5	1,319	6,288
Total	\$362,062	\$280,542	\$342,656	\$471,903

LIST OF LIMESTONE OPERATORS

OPERATOR	OFFICE	QUARRY
Abingdon Construction Co.	Abingdon	Abingdon
Alleghany Lime Co., Inc.	Christiansburg	Houchin Station
Andrews & Co., Inc., T. C.	Norfolk	Norfolk
Beinkampen Lime Co.	Radford	Radford
Bertha Mineral Co., Inc.	Pulaski	Austinville
Bradley, Samuel A.	Newport	Newport
Bristol Lime & Stone Co., Inc.	Bristol, Va.-Tenn	Benhams (near)
Bunn, J. E.	Big Stone Gap	Big Stone Gap
Burks, Jas. L.	Compton Bridge	Saltpetre Cave
Carpenter & Boxley	Roanoke	Pembroke
Carter, Walter H.	Buchanan	Buchanan or Lithia
Childress, J. S.	Christiansburg	Christiansburg
Chiles, C. M.	Strasburg	Strasburg
Church, E. W.	Staunton	Craigsville
Clifton Forge, City of	Clifton Forge	Clifton Forge
Compton, C. W.	Roanoke	Compton Bridge
Compton Bridge Stone Corporation.	Indian Rock	Compton Bridge
Covertson, Eli and Samuel.	Pelton	Seven Fountains
Cram, J. N.	Mossy Creek	Mossy Creek
Cregger, R. C.	Wytheville	Wytheville
Cross & Mays.	Eagle Rock	Eagle Rock
Culbert, W. F.	Marion	Marion
Davidson, S. C.	Max Meadows	Wytheville
Davis, C. W.	Blacksburg	Blacksburg
Dillon's Sons, E.	Indian Rock	Buchanan and Indian Rock
Eagle Rock Lime Co.	Richmond	Eagle Rock
Eureka Lime Co.	Vicar Switch	Vicar Switch
Fellers Stone Co.	Roanoke	Roanoke
Feilsworth Lime Works.	Staunton	Staunton
Fisher & Co., S. E.	Strasburg	Strasburg Jct.
Flickwir, David W.	Roanoke	Roanoke

OPERATOR	OFFICE	QUARRY
Fox, J. W.	Ottobine	Ottobine
Fringer, C. F.	Buchanan	Buchanan (or Lithia)
Gochenour, J. J.	Mauertown	Mauertown
Goshen Iron Co.	Goshen	Bells Valley and Craigsville
Grove Lime Co., M. J.	Limekiln, Md	Stephens City
Haldeman, H. F.	Churchville	Churchville
Hall, George B.	East Radford	Snowville
Harris, J. A.	Stuarts Draft	Stuarts Draft
Herbaugh, Robert L.	Zepp	Zepp
Hoag Co., William N.	Strasburg or New York, Strasburg N. Y.	Strasburg or New York, Strasburg N. Y.
Hogshead, Charles A.	Mossy Creek	Mossy Creek
Horneck Construction Co.	Cumberland	Gate City
Huggins & Co., H. H.	Roanoke	Roanoke
Ivanhoe Furnace Co.	Ivanhoe	Ivanhoe
Keller, J. H.	Fishers Hill	Fishers Hill
Kinzer & Vermillion	Tazewell	Tazewell
Kiracofe, C. S.	Bridgewater	Bridgewater
Kirk, John Y.	West Norfolk	West Norfolk
Kline, J. Harvey	Vaucluse Station	Vaucluse Station
Larner & Co., William	Staunton	Staunton
Leesburg Lime Co., Inc.	Leesburg	Leesburg
Lexington, Town of	Lexington	Lexington
Limeton Lime Co.	Limeton	Limeton
Linville Lime Co.	Linville	Linville
Lowener, C. A.	Harrisonburg	Rockingham
Lone Jack Stone Co.	Lynchburg	Lynchburg
Longdale Iron Co.	Longdale	Longdale
Lowmoor Iron Co. of Virginia	Lowmoor	Lowmoor
Luray Lime Co.	Eura	Luray
McCoy, G. W.	Springwood	Springwood
McGhee & Co., P. R.	Roanoke	Roanoke
McIlwee, C. E.	Zepp	Zepp
McKimmy, A. G.	Luckets	Luckets
Markley, C.	Roanoke	Roanoke
Mathews Curtis Co., Inc.	Clifton Forge	Clifton Forge
May, A. J.	Tazewell	Tazewell
Miller, G. Ed.	Bridgewater	Bridgewater
Moore Lime Co.	Richmond	Eagle Rock
Myers & Neville	Clifton Forge	Clifton Forge
Natural Bridge Lime Co.	Glasgow	Sherwood
New River Lime Co.	Ripplemead	Ripplemead
Oak Ridge Lime Firm	Mt. Solon	Mt. Solon
Oriskany Ore & Iron Corporation	Iron Gate	Mt. Marble
Orndorff, M. M.	Oranda	Oranda
Oyler, Geo. V.	Winchester	Winchester
Powhatan Lime Co.	Strasburg	Strasburg
Pruver, W. W.	Friendship	Friendship
Pulaski Iron Co.	Pulaski	Patterson and Ivanhoe
Pullins, A. C.	Mount Sidney	Mount Sidney
Rawley, N. B.	Churchville	Churchville
Rife Bros.	Timberville	Timberville
Riverton Lime Co.	Riverton	Riverton
Riverton Lime Quarry Co.	Leesburg	Leesburg
Roanoke Stone & Lime Co., Inc.	Roanoke	Lithia

OPERATOR	OFFICE	QUARRY
Rockbridge Lime & Stone Co.	Lexington	Lexington
Rockdale Lime Co.	Toms Brook	Toms Brook
Rule, Pendleton	Abingdon	Abingdon
Sandridge, W. P.	Goshen Bridge	Panther Gap
Shenandoah Iron & Coal Co.	Liberty Furnace	Liberty
Shenandoah Lime Co.	Strasburg Jct.	Strasburg Jct.
Shenandoah Lime & Stone Co.	Strasburg	Strasburg
Shoop Withers Co.	Suffolk	Suffolk
Snarr, G. H.	Wheatfield	Wheatfield
Snyder, E. A.	Buchanan	Springwood
Staunton, City of	Staunton	Staunton
Stickley & Orndorf	Oranda	Oranda
Stoutamine, Jacob	Roanoke	Roanoke
Stuart Land & Cattle Co.	Elk Garden	Elk Garden
Sutton, W. B.	Mendota	Fugates Hill
Tazewell White Lime Works	North Tazewell	North Tazewell
Thompson, T. W.	Hinton	Harrisonburg
Valley Turnpike Co.	Mt. Jackson	Mt. Jackson
Vaughan Construction Co.	Roanoke	Roanoke
Virginia Iron, Coal & Coke Co.	Bristol, Tenn	Barren Springs, Buchanan, and Radford
Webb, J. H.	Roanoke	Roanoke
Wells & Hanger	Staunton	Staunton
West End Furnace Co.	Roanoke	Buchanan
Wheelbarger-Rumsey Lime Corp.	Bridgewater	Bridgewater
Whitesell, D. E.	Stuarts Draft	Stuarts Draft
Woodstock Lime Co., Inc.	Woodstock	Woodstock
Wytheville Town Quarry	Wytheville	Wytheville

SANDSTONE.

Sandstones and quartzites occur in each of the three larger divisions of the State, but quarrying has been limited to only a few of the more accessible areas. There are large areas of these rocks not yet developed because chiefly of their remoteness from lines of railway and large centers.

The principal sandstone and quartzite formations in the State may be classified as follows:

COASTAL PLAIN:

1. Cretaceous sandstones along the "fall-line."

PIEDMONT PLATEAU:

2. Older quartzites in crystalline area of unknown age.
3. Newark (Triassic) sandstones.

APPALACHIAN MOUNTAINS:

4. Cambrian sandstones.
5. Silurian sandstones.
6. Devonian sandstones.
7. Carboniferous sandstones.

Excepting the areas of Triassic (Newark) sandstones, the quartzites and sandstones found east of the Blue Ridge, in the Crystalline area, are of unknown age. There occur an abundance and variety of this type of rock within the limits of the Piedmont. The rock has been quarried in many places, in years past, for use as a general constructional stone, and quarries are operated at present in a number of counties principally for crushed stone for road construction, ballast, and concreting. The stone ordinarily is firm, hard and compact, highly siliceous, very durable, and is admirably adapted to the uses made of it.

The Cretaceous and Triassic sandstones are practically the only ones which have been quarried and the stone shipped beyond the limits of the State. Of these, the Cretaceous sandstone, which occurs along the western margin of the Coastal Plain, was formerly extensively quarried in the vicinity of Aquia Creek and on the Rappahannock River near Fredericksburg. The stone from these quarries was used chiefly in the construction of many of the older public buildings in Washington. These quarries were abandoned many years ago, largely, it is said, because of the unfitness of the stone for exposed work.

There are seven areas of Triassic rocks, composed in part of sandstone, distributed over the crystalline region east of the Blue Ridge. These comprise parts of twenty counties, and are designated as follows: (1) New York-Virginia area, (2) Richmond area, (3) Danville area; (4) Farmville area, (5) Scottsville area, (6) Barboursville area, and (7) Taylorsville area. The Triassic sandstone has been quarried in the vicinity of Manassas, Prince William County, and in the vicinity of Leesburg and Oatlands, Fauquier County. The Manassas quarries have yielded a stone that could be used with pleasing effects in a variety of combinations, and in quality not inferior to that in the more northern and eastern states.

The Cambrian sandstones are chiefly limited in distribution to the western base of the Blue Ridge and have been quarried locally, especially east of Basic, Augusta County, for railroad ballast. Sandstones of Silurian age have wide distribution west of the Blue Ridge, but they vary much in color, texture, and structure. Although possessing the essential properties in places requisite for a general construc-

tional stone, the Silurian sandstones have not been quarried except for immediate local needs. The Oriskany sandstone of Devonian age is generally too friable to make a good building stone.

The Carboniferous comprises the greatest total thickness of sandstones of any single geologic system in the State. The rocks belonging to this system are limited in distribution to certain parts of the region west of the Blue Ridge, and are in part Mississippian and in part Pennsylvanian in age. The Carboniferous sandstones possess those qualities in some localities which make them desirable for building purposes, but as yet they have seldom been quarried, owing largely to a lack of demand for the stone and ample transportation facilities. They have been quarried in places in southwest Virginia for local use as a building stone and for heavy masonry.

The production of sandstone in the State is slight, and it varies greatly according to the local demands. The value of the annual production of sandstone from 1900 to 1910, inclusive, is shown in the accompanying table.

Value of Sandstone production in Virginia, 1900-1910.

Year	Value
1900.....	\$ 6,000
1901.....	5,303
1902.....	2,500
1903.....	4,471
1904.....	13,522
1905.....	2,000
1906.....	5,100
1907.....	(a)
1908.....	2,600
1909.....	28,574
1910.....	25,080

aSmall value included with West Virginia.

LIST OF SANDSTONE OPERATORS

OPERATOR	OFFICE	QUARRY
Gaithers Construction Co.....	Manassas	Nokesville
Hall, L. M.....	Wise	Wise
Mathews Curtis Co., Inc.....	Clifton Forge	Basic City
Peak Creek Sandstone Co.....	Pulaski	Pulaski
Portner Brown Stone Co.....	Manassas	Manassas
Warden & Hailley.....	Pulaski	Pulaski
Wood, J. R.....	Lynchburg	Lynchburg

SLATE.

Slate suitable for roofing and other purposes has been found in many localities within the limits of the State, and quarries have been worked in Albemarle, Amherst, Buckingham, Fauquier, and Fluvanna counties. There are five principal slate areas and several minor belts in Virginia, which, named in the order of their present commercial importance, are: (1) The Arvonia belt in Buckingham and Fluvanna counties; (2) the Keswick-Esmont belt in Albemarle County; (3) the Snowden belt in Amherst and Bedford counties; (4) the Warrenton belt in Fauquier and Culpeper counties; and (5) the Quantico belt in Spotsylvania, Stafford, and Prince William counties. These areas are being studied and mapped by the State Geological Survey when, upon the completion of the chemical and microscopical studies, a volume will be published for distribution. Of the slate areas worked, the Arvonia and Keswick-Esmont belts are commercially the most important at present.

The slate produced in the Arvonia district is the most widely known in the South. The quarries are distributed along Hunts Creek, for some distance north-northeast and south-southwest of Arvonia, a station on the Buckingham Branch of the Chesapeake and Ohio Railway, which is the shipping point. The quarries are very extensive, the largest averaging about 500 feet along the cleavage, 350 feet across, and 350 feet deep. The bedding and cleavage of the slate are identical, striking N. 33° to 37° E., and dipping 70° to 90° southeast, with a probable average of about 85° . The slate is very dark gray in color, with a faint greenish hue; is of minutely granular crystalline texture, and very lustrous surface. According to Dale, it is slightly graphitic and magnetic, does not effervesce in cold dilute hydrochloric acid, and is very sonorous. Dale gives the constituents of the slate in order of their abundance as muscovite and sericite, quartz, biotite, carbonate, graphite (or carbonaceous matter), pyrite, chlorite, magnetite, with accessory plagioclase, zircon, hematite, tourmaline, and rutile.

Although Dale's results on the microscopic study of the Arvonia slate show the presence of some carbonate, an appreciable amount of ferrous carbonate can not be present, for the use of these slates on

buildings in Richmond more than 60 years ago, and on buildings near the quarries for more than a century, shows no discoloration whatever. Strength and durability would naturally follow from the highly crystalline character of this slate.

The Arvonia belt of slate extends for some distance northeastward across the James River into Fluvanna County, and has been opened at several places in the vicinity of Bremo, Fork Union, and Palmyra. Some recent prospecting of the slate in the vicinity of Fork Union and Palmyra, by the Old Dominion Slate and Cement Company, gave most encouraging results as to quantity and quality of the slate, and it is expected that systematic quarrying by this company will be begun at an early date.

About 20 miles west-northwest of the Arvonia belt is the Keswick-Esmont slate belt. It has been prospected at several places, and quarries producing an excellent grade of slate are operating in the vicinity of Esmont.

The Snowden slate belt occurs on the southeast side of the Blue Ridge, in the vicinity of Snowden station, in the southwest part of Amherst County. The belt has been prospected in a number of places, and the Williams Bros. Slate Company has successfully operated a quarry about three miles north-northwest of Snowden. The slate strikes N. 65° E., and has quartzite southeast of it which has been referred to the Cambrian. The cleavage strikes N. 45° E. and dips S. 60° E., and is cut by the original bedding planes which are quite strongly marked at an angle of 45° and more. The slate is very dark gray, has a minutely granular texture, moderately smooth cleavage, but with little lustre. It resembles the Arvonia slate in not effervescing with cold dilute hydrochloric acid and in being quite sonorous, but differs from it in not being graphitic nor magnetic. Arranged in order of abundance, the chief constituents are, according to Dale, muscovite (sericite), quartz, chlorite, kaolin, pyrite, carbonate, rutile, and carbonaceous matter. It is used exclusively for roofing and is a superior slate, though less crystalline than the Arvonia slate.

In Fauquier and Culpeper counties, slate outcrops are traceable to the north and south of the Rappahannock River in the vicinity of White Sulphur springs. The slate outcrops about one mile south of the

springs, and is traced northward for a distance of two miles, with a minimum width of half a mile. The strike of the cleavage over most of the belt is N. 25° to 30° E., with a change in strike to an east-westward direction about three-quarters of a mile south of the springs. The slate is black, of moderately fine texture, and has but little lustre. It is very carbonaceous, shows much pyrite in places, contains no magnetite, does not effervesce with cold dilute hydrochloric acid, and has an argillaceous odor. In the northeasterly opening, Dale gives the chief constituents of the slate, arranged in the order of abundance, as carbonaceous matter, quartz, muscovite, feldspar, pyrite, and chlorite.

Investigations of this belt by the State Geological Survey indicate that pyrite is not present in harmful quantity in all parts of the belt, but that important commercial slate is found, and was quarried on a small scale from a number of openings many years ago, and used locally for roofing purposes.

In Prince William, Stafford, and Spotsylvania counties is one of the most extensive belts of slate in the State. This has been named the Quantico belt by Darton, from the creek by that name. No developments have been made on this belt, and it is not known whether it contains slate of commercial grade or not, but it is being carefully investigated by the State Geological Survey.

The total production of slate in Virginia during 1909 amounted to 40,880 squares, valued at \$180,775, as against 41,678 squares, valued at \$194,356 in 1908, a decrease of 798 squares in quantity and \$13,581 in value. The 1910 production amounted to 31,787 squares, valued at \$148,721. These figures when compared with the 1909 production represent a decrease of 9,093 squares in quantity and \$32,054 in value. In 1910, there were seven producers of slate operating in two counties, namely, Albemarle and Buckingham, with the principal part of the production from Buckingham County. The amount and value of the annual production from 1903 to 1910, inclusive, are given in the accompanying table:

Production of Slate in Virginia, 1903-1910.

Year	Roofing Slate Number of Squares	Value	Average Price Per Square
1903	29,646	\$115,356	\$3.89
1904	31,852	130,208	4.08
1905	36,102	146,786	4.07
1906	39,068	172,857	4.42
1907	37,172	173,670	4.68
1908	41,678	194,356	4.66
1909	40,880	180,775	4.42
1910	31,787	148,721	4.68

The number of squares, as given in the above table, includes both first and second qualities, and the average price per square does not give a fair indication of the prices obtained for most of the stock.

LIST OF SLATE OPERATORS

OPERATOR	OFFICE	QUARRY
Arvonia Slate Co., Inc.....	Lynchburg	Arvonia
Buckingham Slate Co., Inc.....	Richmond	Arvonia
Carbolane Slate Co.....	Esmont	Esmont
Ferncliff Slate Co.....	Rochester, N. Y.....	Arvonia
James River Slate Co.....	New Haven, Conn.....	New Canton
LeSeuer Slate Co., Inc.....	Orebank	Orebank
Old Dominion Slate & Cement Co.....	Palmyra	Palmyra
Penlan Slate Co.....	Penlan	Penlan
Pitts, A. L.....	Arvonia	Arvonia
Richmond Slate Co., Inc.....	Richmond	Arvonia
Standard Slate Corporation	Esmont	Esmont
Victory Buckingham Slate Co.....	Penlan	Penlan
Virginia Slate Co., Inc.....	Arvonia or Farmville.	Arvonia
Williams Bros. Slate Co.....	Snowden	Snowden
Williams Slate Co.....	Arvonia	Arvonia

CRUSHED STONE.

The state-wide interest in good roads construction and improvement, and in the building of new lines of railway in Virginia during the past year, have greatly increased the demand for crushed stone. This material is used exclusively for road-making, railroad ballast, and concrete. The value of the production of crushed stone in Virginia in 1909 was \$470,897 and in 1910, \$474,430, as compared with \$298,614 in 1908.

Road Materials.—The road-building materials of Virginia are abundant and vary greatly in character. Nearly all varieties of stone used in highway construction are found in quantity in many sections of the State. The question of transportation is so important a factor that usually the best materials for road making can not be used in areas far removed from the sources of supply.

In Western Virginia—the Mountain province west of the Blue Ridge—limestones, sandstones, and shales are the principal rocks. Of these, limestone is the best suited for road making. It is found in quantity over most of the region, is easily worked, has good cementing or binding quality, but does not possess the durability of the igneous rocks when used as road metal.

In Middle Virginia—the crystalline area or Piedmont Plateau—the rocks are largely crystalline metamorphic igneous and sedimentary types. These comprise granite, gneiss, schist, and the basic igneous types commonly known as trap, with local areas of slates, limestones, and quartzites. Of these, and in fact of all rocks, the basic igneous types, known as trap, make the best road metal. These rocks are tough and difficult to work, possess a high cementing value, great resistance to wear, and afford a valuable and permanent road metal. These rocks are widely distributed, occurring in practically every county in the Piedmont region.

In Eastern Virginia—the Tidewater or Coastal Plain province—the rocks are of comparatively recent geologic age (late Mesozoic and Cenozoic), and consist chiefly of unconsolidated beds of sand, gravel, clay, and marl, which may be locally indurated by a cement either of iron oxide or carbonate of lime. The gravels and marls, when properly used, are of value in road construction, but they afford a less permanent road metal than the igneous rocks. The oxide of iron and carbonate of lime act as the cementing materials.

Ballast and Concrete.—With the exception of the marls, the materials used for railroad ballast and concrete are the same as those employed in road construction. The requirements are somewhat different from those of good road metal, since little or no binding power is required in railroad ballast, and cementing material is added in concrete.

The value of crushed stone produced in Virginia from 1903 to 1910, by years, is given in the table below.

Value of Annual Production of Crushed Stone in Virginia, 1903-1910.

Year	Granite, Gneiss, Etc.			Limestone			Total
	Road	Ballast	Concrete	Road	Ballast	Concrete	
1903	\$31,785	\$ 17,400	\$ 60,820	\$ 300	\$16,205	\$ 9,238	\$135,748
1904	12,940	61,352	165,043	210	32,371	5,668	277,584
1905	21,175	69,360	166,364	5,254	9,333	11,187	282,673
1906	34,981	64,386	85,077	160	16,050	18,700	219,354
1907	59,937	50,804	167,960	37,000	12,269	32,326	360,296
1908	21,670	92,895	81,745	30,159	45,541	26,604	298,614
1909	74,054	125,704	147,112	31,076	84,883	8,068	470,897
1910	40,691	111,811	156,894	20,056	108,129	36,849	474,430

FURNACE FLUX.

Limestone, used in smelting operations for flux, is quarried and shipped to the numerous blast furnaces in the State. The utilization of limestone as flux constitutes the largest consumption of the Virginia stone. Each of the principal limestone horizons in western Virginia supplies some stone as flux to the iron furnaces, but the Cambro-Ordovician and Lewistown (Helderbergian) limestones are the principal sources of stone for this purpose. Of the total production of limestone in the State in 1909, 62.29 per cent was sold as flux and utilized in the blast furnaces, and in 1910, 62.44 per cent was sold for the same purposes. Table on page 80 shows the total value of the limestone production in Virginia for all uses in 1909 to be \$342,656, of which \$213,444 was the total value of limestone used as flux. The 1910 production of limestone was valued at \$471,903, of which \$294,668 worth was used as flux.

There are given in the table below the annual production and value of limestone as furnace flux in Virginia from 1902 to 1910, inclusive.

Production of Furnace Flux in Virginia, 1902-1910, in long tons.

Year	Quantity	Value
1902.....	565,704	\$ 220,001
1903.....	499,108	199,989
1904.....	273,826	117,882
1905.....	393,662	186,676
1906.....	467,341	219,707
1907.....	541,610	275,517
1908.....	290,487	169,847
1909.....	388,746	213,444
1910.....	540,264	284,668

ABRASIVE MATERIALS.

Under this head are included corundum, emery, and millstones, but in 1909 and 1910 the only abrasive material produced was millstones, which were quarried in Montgomery County.

Corundum and Emery.

The occurrence of corundum and emery has been noted in Virginia, but neither has been produced on a commercial scale.

Corundum.—The principal occurrence of corundum is in Patrick County, about two miles from Stuart, where it occurs on a knob of Bull Mountain, in mica schists. It is a grayish-white to white and colorless and, according to Pratt, is readily cleaned. Tests made for the cleaned product at this locality show that the corundum is well adapted to the manufacture of the vitrified wheel.

Emery.—Emery, a granular corundum of black or grayish-black color and containing magnetite or hematite intimately mixed, is found in considerable quantity a short distance west of Whittles in Pittsylvania County. Two openings about 300 feet apart and 20 feet deep have been made on apparently parallel "veins." Numerous smaller openings have been made near by. The rocks inclosing the emery are probably altered amphibolites or pyroxenites.

Millstones (Buhrstones).

Under this name is included a siliceous conglomerate of quite variable structure, used in the form of flat-circular disks for grinding purposes.

About five miles west of Blacksburg, in the vicinity of Prices Fork, Montgomery County, a sandstone-conglomerate occurs in Brush Mountain, in which quarries have been opened for a distance of three miles. The rock is somewhat variable in color, but is usually of some light shade, white or gray. Likewise variation in the size of the pebble is shown. The rock is made up of well-rounded pebbles of quartz compactly imbedded in a fine siliceous sandstone matrix, the whole forming an exceedingly tough and hard mass. This rock is known on the market as "Brush Mountain" stone. Practically the same variation in the sizes of stone made at the different quarries obtains. The sizes of stone produced in 1910 as reported to the State Survey office were, 12, 14, 16, 20, 24, 26, 30, 36, 42, 48, and 54 inches.

The grindstones made from this rock are of excellent quality and find a ready market. The geologic age of the "Brush Mountain" stone is Mississippian (Lower Carboniferous).

Similar siliceous conglomerates occur in other counties of the State, especially in some of the counties of the Mountain province, but the Brush Mountain quarries, in Montgomery County, are the only producing ones.

The production of millstones in Virginia during 1909 was valued at \$12,348, as against \$7,954 in 1908, an increase in value of \$4,394, or 55.5 per cent. The value of the millstone production for 1910 amounted to \$5,273, a decrease of \$7,075, or nearly 57.3 per cent in comparison with the figures for 1909. The value of millstones produced in Virginia for the years 1902 to 1910, inclusive, follows below in tabular form.

Value of Millstones Produced in Virginia, 1902 to 1910, inclusive.

Year	Value
1902.....	\$ 11,435
1903.....	9,812
1904.....	4,759
1905.....	8,186
1906.....	15,611
1907.....	4,684
1908.....	7,954
1909.....	12,348
1910.....	5,273

LIST OF ABRASIVE OPERATORS

OPERATOR	OFFICE	QUARRY
Olinger, R. L.....	Prices Fork.....	
Price, A. S.....	Prices Fork.....	
Price & Co., B. S.....	Prices Fork.....	Brush Mountain, near
Price & Son, Z.....	Blacksburg.....	
Standard Millstone Co.....	Vicar Switch	Prices Fork

SILICA.

Under this heading are included three forms of silica which have rather wide distribution in the State. These are quartz, chert, and diatomaceous earth.

QUARTZ.

Quartz has wide distribution in the State. It occurs as an essential constituent in granite, gneiss, and mica schist of the crystalline area; as the dominant constituent in the sandstones, quartzites, and conglomerates of the Piedmont and Valley regions; and in the form of sand over parts of each of the larger geologic divisions of the State. A principal occurrence of quartz in Virginia, that is of commercial value, is in the form of pegmatite dikes and quartz veins penetrating the older metamorphic rocks of the Piedmont region.

There was no reported production of quartz in 1909 and 1910.

CHERT.

Chert, known also as hornstone, a term applied to any impure flinty rock, including the jaspers, is a chalcedonic variety of silica. Chert has wide distribution in certain beds of the Shenandoah or Valley limestone of the Valley region, in the form of irregular nodular masses of light nearly white, red, brown, and black colors. No special use has yet been made of the Virginia chert.

DIATOMACEOUS EARTH.

Diatomaceous earth, known in the trade under the name of "silica," "infusorial earth," or "tripoli," is composed of minute shells or tests of microscopic plants known as diatoms. It was first reported from the vicinity of Richmond, Virginia, and for that reason received the name of "Richmond earth," under which term it is sometimes referred to in the literature. Because of its occurrence at Bermuda Hundred, on the James River, it has also been called "Bermuda earth."

The first bed of diatomaceous earth of any extent discovered in this country was in the Richmond area. It is known as the Richmond bed, which extends from Herring Bay on the Chesapeake, Maryland, to Petersburg, Virginia, and probably beyond. It is not less than 30 feet in thickness in places, though very impure at times. It is of Miocene age, and is exposed along the numerous streams close to their crossings from the crystalline rocks on to the sediments of the Coastal Plain.

The diatomaceous earth has been dug from time to time in the vicinity of Richmond for commercial use. There has been no reported production of this material in Virginia for several years.

MICA.

Commercial mica, which includes the varieties known as muscovite and phlogopite, usually occurs in pegmatite dikes penetrating granites, gneisses, and schists. The pegmatites usually consist of a coarse crystallization of quartz and feldspar in varying proportions, with or without mica, and other accessory minerals. They vary in thickness from a few inches to several hundred feet, are often irregular in outline, and may be parallel to or break across the schistosity of the inclosing rocks. In small veins the mica is frequently too small in size to have commercial value. Both the quartz and the feldspar of the pegmatites are of value, and are sometimes mined with the mica and utilized in the manufacture of pottery and for abrasives.

Pegmatites containing commercial mica are somewhat abundantly developed in many of the Virginia Piedmont counties, and many excellent surface indications for mica occur, but as yet prospecting and mining have been confined to only a few of them. Mica has been either prospected or mined in the following counties in Virginia: Near Amelia and Jetersville, Amelia County; near New London and at Lowry, Bedford County; Goochland County; near Chatham, Pittsylvania County; near Axton and at Ridgeway, Henry County; near Hewlitts, Hanover County; near Farmville and at Prospect, Prince Edward County; Amherst and Charlotte counties. Indications of mica occur also in Buckingham, Caroline, Cumberland, Franklin, Powhatan, and Spottsylvania counties.

The mica of the Amelia County district occurs in pegmatites cutting a thinly foliated, biotite gneiss, which, in places, shows a distinct "augen" texture. The proportion of mica, quartz, and feldspar in the pegmatites is quite variable. The feldspar varieties include orthoclase, microcline, and albite. A considerable number of accessory rare minerals have been found in the Amelia pegmatites, and some of them have been used for gems. More than a half dozen mines have been opened in the county, but the Pinchbeck and Schlegal mines are the only ones that have been worked for mica in recent years.

The mines owned by the Hanover Mica Company, near Hewlitt, in Hanover County, were the first mines worked for mica in Virginia. These were first worked from 1867 to 1870 by Barr, Johnson and Company, of Erie, Pennsylvania, with a production of more than 60,000 pounds of clipped stove mica. Regular mining has not been engaged in within recent years, although about 1,000 pounds of rough mica of excellent grade and clear white color were worked from the mines during the fall of 1907. Some of this was reported to be about 18 by 33 inches in size.

The Pittsburg Mica Company's mine at Ridgeway, Henry County, was developed by an open cut about 100 feet long and 40 feet deep, and much cross-cut work. The plant completed at the mine in 1907 was destroyed by fire in 1908, which greatly curtailed the production of mica by the company for that year.

The production of mica in Virginia during 1909 was 7,833 pounds of sheet mica and 75 tons of scrap, with a total valuation of \$4,600, and was obtained from three producers. There was no production of mica reported in 1910.

LIST OF MICA OPERATORS

OPERATOR	OFFICE	MINE
American Asbestos Co.....	Terre Haute, Ind.....	Bedford City
Cole, A. L.....	Chatham	Chatham
Corson, F. W.....	Waymart, Pa.....	Amelia
Corson Mica Co., Inc.....	E. Stroudsburg, Pa.....	Amelia
Hanover Mica Co.,.....	Hewlett	Hewlett
Henry Mica Corporation.....	Columbus, Ohio	Martinsville
Mecklenburg Mica & Mining Co.....	Petersburg	Petersburg
Otto Hill Mica Mines:.....	Findlay, Ohio	Bedford City
Patterson, J. M.....	Washington, D. C.....	Amelia County
Pinchbeck Mica Mines.....	Chula	Amelia Courthouse
Roanoke Mica Mining Co.....	Francisco, N. C.....	Roanoke
Watton & Fontaine.....	Axtion	Martinsville

FELDSPAR.

The feldspar group includes a number of mineral species which chemically are silicates of aluminum with varying amounts of lime, and the alkalis, potash and soda. Of the nine known species of feldspar only a few are of commercial value, the principal ones being the potash varieties, orthoclase and microcline, and the soda variety, albite. Orthoclase or microcline, or an intergrowth of these two, are the species most commonly used by potters in this country. The potash feldspars are frequently associated with small quantities of the soda feldspar, albite, which occurs either as separate crystals or intergrown with the orthoclase or microcline.

Commercial feldspar usually occurs associated with quartz and mica as coarse crystallizations in pegmatite dikes, cutting granites, gneisses, and crystalline schists. Pegmatites are rocks usually of extreme coarseness and of irregular texture and composition. Dikes of pegmatite containing feldspar as an important constituent are quite widely distributed throughout the Virginia Piedmont region, hardly a county within the region being without them. Notwithstanding the abundance of these dikes in the Virginia Piedmont province, many of which contain commercial feldspar, the attempts to mine the mineral are comparatively few, and as yet the production is small and variable. Feldspar has been mined in Amelia, Bedford, Hanover, Henry, and Prince Edward counties. In a majority of these counties feldspar has been mined with the associated mica of the pegmatites.

In order to avoid disclosing individual figures, the production of feldspar in Virginia for the years 1909 and 1910 is combined with that of another subject.

LIST OF FELDSPAR OPERATORS

OPERATOR	OFFICE	MINE
Bedford Spar Co.	Roanoke	Bells
Dominion State Mines Corporation.....	Farmville	Prospect
Patterson, J. Murrell.....	Washington, D. C.	Amelia County
Pinchbeck, W. L.....	Chula	Amelia
Schlegal	Jetersville	Jetersville

ASBESTOS.

Prior to 1907, Virginia was a producer of asbestos for a number of years. No production has been reported during the last four years. The mineral has been noted in a number of the Piedmont counties, and it has been mined in Amelia, Bedford, and Franklin, principally the two latter. The mines have been inactive since 1906 and the mill at Bedford City for fiberizing the asbestos is closed, though there is a probability that it will be in operation again in the near future.

In Bedford County, the mines of the American Asbestos Company are located near Chestnutfork post-office, about 12 miles south of Bedford City, on the Hubbard farms. According to Diller^a, the asbestos rock is of two types. The first type is like that of Sall Mountain, Georgia, and is composed essentially of fibrous amphibole, the fibers of which are arranged in groups or bundles lying in all directions, and is derived from pyroxenite. The other type is a peridotite composed chiefly of granular olivine, with numerous acicular crystals and fibrous bundles of anthophyllite. Diller^b states that this type is cut by a few small veins of cross-fiber anthophyllite, one-eighth to three-quarters of an inch in length. The fiber is flexible, somewhat elastic, has numerous cross fractures, and is relatively short and brittle. The asbestos mined occurs as vein-like masses of slip fiber, lying parallel to the plane of slipping, which cut the rock as occasional planes of shearing. These masses are very irregular, locally 18 inches thick, and along the strike have a length of about 30 feet.

In Franklin County, a small amount of asbestos was recently mined from a 40-foot shaft a short distance east of Rocky Mount. The asbestos-bearing rock^c is amphibolite, which locally contains some olivine, and is much altered to chlorite and serpentine. The asbestos is found in a vein which lies parallel to the schistosity of the inclosing amphibolite, with strike S. 50° E. and steep dip to the northeast. The principal constituent is probably tremolite.

^aDiller, J. S. Mineral Resources of the United States, Part II, Nonmetallic Products, 1907, p. 718.

^bIbid., pp. 718-719.

^cIbid., p. 719.

LIST OF ASBESTOS OPERATORS

OPERATOR	OFFICE	MINE
American Asbestos Co.....	Terre Haute, Ind.....	Chestnutfork
Heermance, E. Van Ness.....	New York, N. Y.....	Rocky Mount
Hubbard, L. F.....	Body Camp	Body Camp
Pine Mountain Mica & Asbestos Co.....	Richmond	
Smithers, W. C.....	Rocky Mount	Rocky Mount

TALC AND SOAPSTONE.

Virginia is by far the most important state in the United States in the production of soapstone, which has wide distribution over the Piedmont region. It has been noted in the following counties: Albemarle, Amelia, Amherst, Bedford, Buckingham, Campbell, Carroll, Charlotte, Fairfax, Floyd, Fluvanna, Franklin, Grayson, Henry, Louisa, Nelson, Patrick, and Stafford. Many of the deposits are of excellent grade, and the stone has been quarried on a commercial scale in at least six of the above-named counties; but practically the entire production in Virginia at present comes from the Nelson-Albemarle counties belt.

In Fluvanna and Buckingham counties, soapstone was quarried many years ago on a small scale near the mouth of Hardware Creek, and the product used locally for hearths, jambs, and other parts about chimneys. It has also been made use of further east in the southern part of Fluvanna County, at Bremo, and a good grade of it occurs at several localities in the vicinity of Palmyra.

In Albemarle County, a little west of Green Mountain, is a belt of soapstone associated with quartzites and micaceous schists, which is traced southwestward through Nelson into Campbell, Bedford, and Franklin counties. The belt widens in Nelson County and is associated with some serpentine. It passes thence as a narrow belt along the western base of Buffalo Ridge, in Amherst County, crossing the James River above Lynchburg, and is exposed about two miles west of the city on the road leading to Bedford City, and is exposed again two and a half miles west of New London in Bedford County. Continuing in the same direction, the stone is seen again at the meadows of Goose Creek, where it has been quarried to some extent. Continuing still further westward, it is exposed in several nearly parallel belts, of which the most eastern makes its appearance near Pig River in Franklin

County. A second belt occurs in the same vicinity near the eastern base of Jack's Mountain; a third still further west about one mile from Rocky Mount; and a fourth yet more to the west on the eastern slope of Grassy Hill. The stone has been quarried in a small way at several places in Franklin County, near Rocky Mount, and used strictly for local purposes. Extensive quarrying operations are in force in the Albemarle-Nelson counties' portion of the belt, which is described below.

In Amelia County, south of Chula, and about four miles from Amelia, soapstone of good quality was quarried quite extensively many years ago. A second more extensive area of soapstone of excellent quality occurs on the north side of Flat Creek, about four and a half miles north of Jetersville. On the headwaters of Walnut Creek, a tributary to Flat Creek, soapstone has been quarried to some extent. Quarrying was begun in 1904, and during the summer of 1906 numerous other smaller openings were made nearby. This property is controlled by the Tip Top Soapstone Company, and much preliminary work was in progress during 1908 preparatory to systematic quarrying in 1909.

In Louisa County, soapstone of good quality is reported to have been quarried near Oakland and Trevilians.

In Fairfax County, soapstone occurs two miles east of Annandale, one mile east of Tenley, and east of Falls Church. In each of these localities, the soapstone occurs as lenticular bodies closely associated with basic eruptive rocks, and were probably derived from peridotite and pyroxenite. All of these bodies have been worked to some extent, and in the Annandale area much stone has been quarried and sawed. The stone is of good quality, even-grained, and of uniform light bluish-green color, without seams and schistose planes developed in it. Small quarries of soapstone are operated in Fairfax County, near Clifton and Wiehle. At the former, soapstone is ground, but at Wiehle it is sold in the crude state just as it is taken from the quarry.

In Henry County, near Spencer's store, quarries of soapstone were opened some years ago. The material was of excellent quality, and blocks of any required dimensions were reported to have been

quarried. These were sawn out and then finished by planing. They were used in the foundations of houses and for other purposes.

In Albemarle and Nelson counties, the soapstone belt is a short distance west of Green Mountain, and, to the east, near and approximately parallel to, Hawkins, Finley, Ball, and Appleberry mountains. It has a general northeast-southwest direction, and is three to five miles southeast of the main line of the Southern Railway, which it roughly parallels. Quarries have been opened on the belt at numerous points for a distance of nearly 30 miles. Several of the most extensively worked quarries have reached depths of more than 120 feet. The larger quarries are well equipped with all necessary modern machinery for getting out the stone, including channeling machines for quarrying the rock, and at each quarry is a mill for sawing, dressing, rubbing, and polishing the stone, and other machines for grooving and drilling holes. The excellent quality of this stone adapts it to a wide range of uses, the principal ones including laundry tubs, sanitary purposes, electrical purposes, sinks, and cooking utensils.

In Stafford County, soapstone of good quality occurs near Garrisonville.

The production of talc and soapstone in Virginia during 1909 showed a marked increase over that of 1908. The figures were 26,511 short tons, valued at \$523,942, as compared with 19,616 short tons, valued at \$458,252 in 1908, an increase in quantity of 6,895 tons, and in value of \$65,690, or 14.3 per cent. The 1909 production was obtained from 11 producers, operating in five counties, namely, Nelson, Fairfax, Albemarle, Amelia, and Campbell. Only a small proportion of the total quantity of talc and soapstone quarried in Virginia is sold in the crude state. The talc and soapstone production is classified in the following four groups: Rough or crude, sawed into slabs, manufactured articles, and ground.

The production of talc and soapstone in Virginia during 1910 amounted to 25,908 short tons, valued at \$510,781, as compared with 26,511 short tons, valued at \$523,942 in 1909. These figures represent a decrease in quantity of 603 tons, and in value of \$13,161, or 2.5 per cent. The 1910 production was obtained from 9 producers operating in four counties, as against 11 producers operating in five counties.

during 1909. Although there was a decline in the total production, practically half of the quarries operating increased in production. The 1910 production was from the four following counties: Albemarle, Campbell, Fairfax, and Nelson. Of the total production, 1,388 tons were sold as crude tale, and 2,502 tons were sold in the form of slabs. More than 82 per cent of the production was sold as manufactured products, chiefly as laundry tubs.

In the following table are given the quantity and value of tale and soapstone produced in Virginia during the years 1909 and 1910, according to the condition in which it was marketed.

Production of Talc and Soapstone in Virginia during 1909 and 1910, according to varieties.

	1909		1910	
	Quantity Short tons	Value	Quantity Short tons	Value
Rough }	2,150	\$ 9,450	2,108	\$ 8,364
Ground ^a }	2,868	53,859	2,502	47,542
Sawed into slabs.....	21,493	460,633	21,298	454,875
Manufactured articles ^b ..				
Total	26,511	523,942	25,908	510,781

^aFor paint, paper filling, complexion powders, lubricants, etc.

^bIncludes washtubs, laboratory or kitchen sinks, stove bricks, griddles or other mill stock.

There is given in the table below the yearly production of talc and soapstone in Virginia from 1905 to 1910, inclusive:

Production of Talc and Soapstone in Virginia, 1905-1910, in short tons.

Year	Quantity	Value
1905.....	17,665	\$425,090
1906.....	23,624	590,800
1907.....	26,278	631,880
1908.....	19,616	458,252
1909.....	26,511	523,942
1910.....	25,908	510,781

LIST OF TALC AND SOAPSTONE OPERATORS

OPERATOR	OFFICE	QUARRY
Austin Run Mining Co.	Philadelphia, Pa.	Garrisonville
Bull Run Talc & Soapstone Co.	Clifton Station	Clifton Station
Climax Soapstone Co.	New York, N. Y., or Elmington	Elmington
Cuthbert Land & Development Co.	Wiehle	Wiehle
Eureka Soapstone Co.	Shipman	Shipman
Fairfax Soapstone Co.	Wiehle	Wiehle
Gilmore, W. J.	Louisa	Louisa
Hester Estate, B. H., W. S. Buchanan, Mgr.	Trevilians	Trevilians
Hutchinson, H. B.	Washington, D. C.	Shipman
National Soapstone Co.	New York, N. Y.	Wiehle
Old Dominion Soapstone Corporation	Esmont	Damon
Otter River Stone Co.	Bramwell, W. Va.	Lynch Station
Phoenix Soapstone Co.	New York, N. Y.	Arrington
Piedmont Soapstone Co.	Boston, Mass.	Asbestine
Pinkerton, W. A.	Alberene	Alberene
Tip Top Soapstone Co.	Philadelphia, Pa.	Jetersville
Virginia Soapstone Co.	Schuyler	Alberene and Schuyler

BARYTES.

Barytes has been mined for many years in various parts of the State. It occurs in many counties, but the industry has been confined to only a few of them. The counties in which it is found are: (1) those east of the Blue Ridge in the crystalline area, and include Amherst, Bedford, Buckingham, Campbell, Fauquier, Louisa, Nelson, Orange, and Prince William; and (2) those counties west of the Blue Ridge, and comprise Bland, Botetourt, Frederick, Montgomery, Rockbridge, Russell, Scott, Smyth, Tazewell, Warren, Washington, and Wythe. Of these, Bedford, Campbell, Pittsylvania, and Prince William counties, of the Piedmont province, and Russell, Smyth, and Tazewell counties, of the Mountain province, have practically yielded the entire production of the State.

Geologically, the barytes deposits found in the Piedmont region are associated either with the crystalline metamorphic rocks (limestone, chiefly) of probable Cambrian age, or with the Triassic red shale-sandstone series, and those of the Mountain region are usually associated with the Shenandoah limestone of Cambro-Ordovician age or its residual decay.

In the Triassic area of Prince William County, barytes mined about four miles south of east from Catlett is associated with red shale and impure limestone, usually filling fractures of variable width

in the red shale, and in thin, tabular, cleavable masses in the limestone. During 1908, deposits of barytes of good quality and in quantity are reported to have been opened in the vicinity of Bealton, Fauquier County.

In the crystalline area, the principal production of barytes has been from Campbell, Bedford, Louisa, and Pittsylvania counties. The Campbell-Pittsylvania counties area is traced for a distance of about 50 miles southwestward, beginning in the middle western portion of Campbell County, several miles east of Evington, and about 15 miles south of Lynchburg to three or more miles south of Sandy Level, in the northwestern part of Pittsylvania County. The most extensively worked deposits in this area are grouped about two centers, Evington, in Campbell County, at the northeast, and Toshes and Sandy Level, in Pittsylvania County, at the southwest extremity of the area.

The barytes in the extreme northwest corner of Pittsylvania County has been more extensively worked than in any other part of the belt. It has been developed by a large number of mines, grouped in two nearly parallel belts on either side of Pig River, just south of its entrance into Roanoke River.

Numerous openings have been made at different points on the belt between the two centers mentioned above, many of which have been extensively worked and have produced large quantities of excellent ore. The barytes occurs in the Campbell-Pittsylvania counties belt in intimate association with the crystalline limestone as irregular lenticular bodies or pockets, which measure from 100 to 200 feet or more, replacing the limestone. For the depths thus far attained in mining, there is immediately above and below the limestone, a variable thickness of a nearly black clayey mass, usually preserving the foliation of the original rock from which it was derived, and colored black from manganese oxide. Through this black clayey mass are usually distributed, in irregular fashion, lumps and nodules of barytes of large and small sizes.

Near Thaxton, in Bedford County, barytes occurs filling a fracture in a foliated granite of coarse grain. About three miles south of east from Lindsay, in Louisa County, barytes has been mined from a number of test pits and several shafts. The barytes occurs in pockets

having a thickness of about three feet where worked, and probably represents a filling of an irregular fracture in the crystalline schists.

In southwest Virginia, the barytes is found in association with the Shenandoah limestone or its residual decay. It fills in part, at least, fractures in the limestone, and in part it replaces the limestone. In the clay derived from the weathering of the limestone, the barytes is found in nodules of large and small size irregularly distributed through the clay.

The production of barytes for the years 1909 and 1910, respectively, can not be published separately without disclosing individual figures, hence it is combined with another subject. There were two active producers in Virginia in 1910, and the production of refined barytes was reported by one mill.

The following table gives the quantity, total value, and average price per ton of the barytes produced in Virginia from 1902 to 1908.

Production of Crude Barytes in Virginia, 1902-1908, in short tons.

Year	Quantity	Value	Average price per ton
1902	12,400	\$39,700	\$3.20
1903	5,700	20,400	3.58
1904	11,214	31,452	2.84
1905	6,468	27,838	4.30
1906	11,775	45,336	3.85
1907	9,254	32,833	3.55
1908	3,866	17,572	4.55
1909	(a)	(a)	(a)
1910	(a)	(a)	(a)

aCombined with another subject in order to conceal figures of production, there being only two producers during the years 1909 and 1910.

LIST OF BARYTES OPERATORS

OPERATOR	OFFICE	MINE
Berg, Henry	Verona, Pa.	Richland
Clinch Valley Barytes Co.	Honaker	Honaker
Langhorne, R. H.	Evington	Evington
Marks, S. B.	Leesville	Leesville
Nulsen, Klein & Krausse Manufacturing Co.	St. Louis, Mo.	Tosches
Pittsburg Baryta & Milling Corporation	Pittsburg, Pa.	Russell and Tazewell counties
Williams & Son, John T.	Bristol, Tenn., or New Roanoke County (?) York, N. Y.	

GYPSUM.

Commercial deposits of gypsum in Virginia occur associated with salt in Washington and Smyth counties, in the valley of the North Fork of the Holston River. They are associated with rocks of Mississippian (Lower Carboniferous) age. They are limited to the narrow belt on the northwest side of the Saltville fault, included between the fault and the Carboniferous shales and sandstones of the basal slopes of Pine and Little Brushy mountains. So far as has been made out, this narrow belt is composed of the Greenbriar limestone (Lower Carboniferous), and the beds of salt and gypsum.

Gypsum of excellent quality has been mined at numerous points in the Valley between Plasterco and within three miles west of Chat ham Hill. The mines of the United States Gypsum Company at Plasterco, Washington County, and the Southern Gypsum Company, three and a half miles northeast of Saltville, Smyth County, are the most extensive in the valley and were the only ones that produced in 1910. The production of gypsum in Virginia in 1909 is included under "Other products" in table on page 5, in order to avoid disclosing individual production, since there were only two producers. The 1910 production of gypsum is included under the same heading in table on page 6.

An underground examination of the gypsum, in the openings at Plasterco, indicates the occurrence of gypsum with much admixed anhydrite in huge boulder masses, in gray and red clays. Both clays are abundant, the red being softer than the gray and is utilized to some extent in the manufacture of plaster. The gypsum as mined is ground and calcined at the milling plant located at the mines, and the product is used chiefly as calcined and wall plasters, and as land plaster.

The Southern Gypsum Company began prospecting on its property, three and a half miles northeast of Saltville, in the summer of 1906. After nearly a year of drilling, the company demonstrated a large supply of gypsum and erected a mill with the capacity of 400 tons per day. The product of this company is put upon the market chiefly in the form of wall plaster and land plaster.

LIST OF GYPSUM OPERATORS

OPERATOR

OFFICE

MINE

Buchanan, D. J. & W. W.....	Chatham Hill	Chatham Hill
Southern Gypsum Co., Inc.....	North Holston	North Holston
U. S. Gypsum Co. ^a	Chicago	Plasterco

^aFormerly Buena Vista Plaster and Mining Co., Plasterco.

SALT.

Salt brines and rock salt occur in the Holston Valley of southwest Virginia in association with gypsum. The salt and gypsum deposits are confined to a narrow northeast-southwest valley of the North Fork of the Holston River, extending from Plasterco to within three miles of Chatham Hill, a distance of about 16 miles. The interbedded salt and gypsum shales with beds of rock salt and gypsum are regarded as of Mississippian (Lower Carboniferous) age.

A shaft was sunk in 1840 which struck a bed of rock salt at a depth of 210 feet. A large number of wells have been bored, ranging in depth from 300 to 1,400 feet, the greatest depth reached being 2,380 feet. The first borings for salt in this valley were in the old swampy lake-covered area near the present site of the town of Saltville. Mining of the rock salt has not been attempted, the entire salt product being derived from the salt brines of the wells. The entire salt industry at present is confined to the immediate vicinity of Saltville, and is controlled by the Mathieson Alkali Works.

In the early history of operations and, indeed, until within recent years, the product marketed was salt, which for many years amounted to between a half million and a million bushels of salt per year. The Mathieson Alkali Works stopped the making of salt in 1903, and from that time until 1908 the brines were utilized exclusively for the manufacture of sodium carbonate and caustic soda. The product was of superior merit from the start, and, because of this fact, a large and growing trade has been acquired. The manufacture of salt was again resumed in 1908 by the company, but, since there was only one operator, the figures of value of the production had to be combined with those of another subject, in order not to disclose private business. The same condition holds in respect to the production for the years 1909 and 1910, hence the figures are combined with those of another subject.

MINERAL PAINTS.

Ocher of more or less purity is found, and has been mined to some extent in each of the principal geologic divisions of the State, namely, the Coastal Plain, the Piedmont Plateau, and the Valley region. It has been mined at the following localities in Virginia: In the extreme eastern part of Chesterfield County, near Bermuda Hundred, on the Appomattox River; in the Little Catoctin Mountain, near Leesburg, in Loudoun County; near Bedford City, in Bedford County; near Keezletown, in Rockingham County; from the western base of the Southwest Massanutton Mountain, near Stanleyton, in Page County; and near Shenandoah Station, in Page and Rockingham counties.

In addition to these, ocher deposits are found rather widely distributed over the Valley and Piedmont provinces, and to some extent over the Coastal Plain, which have not been worked. In the Valley and Piedmont provinces, the ocher deposits are frequently associated with beds of iron ore. Deposits of ocher varying in color from red, yellow, and brown, and which seem particularly promising but not yet developed, are found in Campbell and Bedford counties; near Bon Air, in Chesterfield County; near Fairfield, in Rockbridge County; near Waynesboro, in Augusta County; and near Roaring Run, in Craig County. The production of ocher in Virginia during 1909 and 1910 is combined with another subject in order to avoid disclosing individual figures.

LIST OF MINERAL PAINT OPERATORS

OPERATOR	OFFICE	MINE
Bermuda Ocher Co.....	New York	Bermuda Hundred
Butterworth, R	Butterworth	Pride
Frazer Paint Co.....	Detroit, Mich	Bedford City
Stigleman, W. T.....	Snowville	Snowville
Virginia Ocher Corporation. ^a	Irwin, Pa	Stanleyton

^aFormerly Page Ocher Corporation, Stanleyton.

MARL.

Calcareous and greensand marls are widely distributed over the Coastal Plain or Tidewater region of Virginia. Calcareous marls are also found in places in the Valley region west of the Blue Ridge. They have not been developed in Virginia, however, except for local use.

The greensand marl is Eocene in age, and is formed chiefly along the inner margin or western portion of the Coastal Plain, where it is

exposed along the Potomac, Rappahannock, Pamunkey, and James rivers. It also occurs on the interstream areas, and has been traced southward from the James River almost to the State line. The green-sand marls contain a small percentage of potash and frequently phosphoric acid, the potash content varying according to the quantity of the mineral glauconite present. Shells are usually present in the deposits and supply lime in addition to potash and phosphoric acid. These marls have value as a fertilizer, and have been worked at a number of places on the James and Pamunkey rivers.

The calcareous (shell) marls are abundant over much of the Coastal Plain region, being especially so in the Miocene and, in places, hardly less abundant in the Eocene. The deposits are quite extensive in some localities, and contain as much as 80 to 97 per cent of calcium carbonate in places. In addition to their agricultural value, many of the beds are large enough and of sufficient quality to be used in the manufacture of Portland cement. The State Geological Survey has had under investigation these deposits with a view to their use in Portland cement manufacture, and a plant has been erected at Norfolk by the Norfolk Portland Cement Company for the manufacture of cement from these marls. Charters have been granted the Jamestown Portland Cement Corporation and the Colonial Portland Cement Corporation for the erection of plants and the manufacture of cement from marls and clays at Yorktown and near Grove Station. It is hardly necessary to call attention to the advantages afforded in this region to water transportation.

There was no production of marls in Virginia during the years 1909 and 1910.

PYRITE AND PYRRHOTITE.

The tabulation of production and value of pyrite in Virginia by years, given on page 111, includes both pyrite and pyrrhotite. Virginia has long held the position of first producer of pyrite among the pyrite-producing states in the United States.

Commercial pyrite occurs in Louisa, Stafford, Spotsylvania, and Prince William counties. Mines are opened in each of these counties, but the production has been from Louisa and Prince William counties. The pyrite mines in these two counties are probably the largest and

most extensively developed ones in the United States, and the product from them constitutes nearly 50 per cent of the total output of pyrite in the United States.

The pyrite mines in Louisa County were worked at different times for iron, copper, and pyrite. They were first opened and worked for iron in 1834, when the gossan overlying the pyrite for a depth of from 40 to 60 feet was mined for iron-making in the local furnaces. The Prince William County mine, near Dumfries, was first opened in 1889, but was not continuously operated until several years later.

The pyrite deposits in Louisa and Prince William counties occur as lenticular bodies, usually of large size, lying conformable or nearly so with the structure (foliation) of the inclosing rock. The lenses follow each other in the direction of strike, and may or may not be connected by thin and lean stringers of ore. The spacing between the ends of lenses is variable. In a few instances, partial overlap of the lenses has been observed. The lenses vary much in size, those in the Louisa County mines measuring several hundred feet long and as much as 60 to 80 feet in thickness.

As developed by the extensive mining operations, the ore-bodies are marked, in places, by rolls and swells and by pinching and narrowing. The inclosing rocks are metamorphic crystalline schists, chiefly micaceous, with more or less of the minerals, hornblende and garnet, developed in places. The normal rock is a mica-quartz schist, but mica schist without quartz, largely altered to chlorite, quartz-sericite schist, talcose and chloritic schists, and hornblendic schist, occur. Bands and stringers of more or less pure limestone are found in the walls near the ore bodies. Associated with these, is a considerable development of lime-bearing silicate minerals.

The ore consists of the massive-granular type, which varies in texture from very fine- to moderately coarse-grained. Some of it is very hard and non-friable, but much of it is quite friable, and in some mines practically all the ore is of the latter type. Much of the ore is admixed with white granular calcite and some quartz. Chalcopyrite, sphalerite, galenite, pyrrhotite, and magnetite are associated with the pyrite in small quantity. Chalcopyrite is present in sufficient quantity at some mines to warrant the saving of the copper from

time to time by precipitation of it from the mine water, when it is dried, screened, and barreled for market. Sufficient chalcopyrite is encountered in the Cabin Branch pyrite mine near Dumfries, in Prince William County, to warrant the building recently of a small smelter for the extraction of the copper.

The principal occurrence of pyrrhotite in Virginia is that of the "Great Gossan Lead" in Floyd, Carroll, and Grayson counties. This "lead" forms a well-defined vein of pyrrhotite varying in width up to 100 feet, and strikes southwestward from Floyd County, through Carroll into Grayson County, a distance of more than 20 miles. It is composed chiefly of pyrrhotite with admixed quartz and schist, and carries streaks and patches of chalcopyrite and pyrite. The vein fills a fault fracture in crystalline schists of unknown age, varies in width from a few feet up to 100 feet, shows a somewhat variable but average dip of about 45° , and has in general an approximate northeast trend. At present, pyrrhotite is mined by the Pulaski Mining Company near Monarat, Carroll County, and the ore treated at Pulaski for sulphur.

The total production of pyrite, including pyrrhotite, in Virginia during 1909, showed a decrease of 2,164 long tons, or 1.86 per cent, in quantity, and \$12,239, or 2.81 per cent, in value, in comparison with the figures for the previous year. The production in 1909 was 114,176 long tons, valued at \$423,283, as compared with 116,340 long tons, valued at \$435,522 in 1908. The average price per ton of pyrite in Virginia during 1909 was \$3.71, as compared with \$3.74 in 1908. The 1910 production of pyrite showed a considerable increase over the 1909 production, the figures for 1910 being 140,106 long tons, valued at \$525,437. It will be seen from these figures that there was an increase over the production for 1909, of 25,930 tons in quantity and \$102,154 in value. The average price per ton advanced from \$3.71 in 1909 to \$3.75 per ton in 1910.

There is given in the table below the production of pyrite in Virginia from 1904 to 1910, inclusive.

Production of Pyrite in Virginia, 1904-1910, in long tons.

Year	Quantity	Value	Average price per ton
1904	120,671	\$440,753	\$3.65
1905	123,183	426,008	3.46
1906	128,794	431,388	3.35
1907	124,740	372,586	2.99
1908	116,340	435,522	3.74
1909	114,176	423,283	3.71
1910	140,106	525,437	3.75

LIST OF PYRITE OPERATORS

OPERATOR	OFFICE	MINE
Arminius Chemical Co.....	Mineral	Mineral
Austin Run Mining Co.....	Philadelphia, Pa.....	Garrisonville
Braun, Johannes	Passaic, N. J.....	Green Bay
Cabin Branch Mining Co.....	Baltimore, Md	Dumfries
Hardy, W. N.....	Church Road	Iona
Louisa Mining Co.....	Cuckoo	Mineral (near)
Pulaski Mining Co.....	New York, N. Y.....	Monarat
Spottsylvania Sulphur Mines Co.....	Holladay	Holladay
Sulphur Mining & Railroad Co.....	Richmond	Mineral
U. S. Fidelity & Guaranty.....	Baltimore, Md	Mineral
Williams & Son, John T.....	Bristol, Va.-Tenn.....	Bonsacks

ARSENIC.

Virginia has not been a producer of arsenic for several years. In 1903, the United States Arsenic Mines Company, of Pittsburg, Pennsylvania, began the mining of arsenopyrite (mispickel) at Brinton, in Floyd County. An extensive plant, erected for refining the product, was started in 1904, with the monthly capacity increased after January, 1905, to 90 tons of pure white arsenic. Operations were temporarily abandoned several years ago, and owing to the low price of white arsenic the Floyd County mines did not operate in 1909 and 1910. A company was organized in 1910 to manufacture Paris green from the white arsenic made at the Floyd County arsenic mine, and a plant was established at Norfolk, Virginia.

The mines are located 14 miles southeast of Christiansburg, at Brinton, Floyd County. The ore is arsenopyrite, a double sulphide of arsenic and iron, associated with pyrite, and occurs in "veins"

(lenses) in quartz-sericite schist, which is closely associated with a variable biotite gneiss, but the relations of the two rock types to each other, and of the gneiss to the ore bodies, are unknown.

PHOSPHATE.

Three forms of phosphatic material occur in the State; namely, (1) the marls of the Coastal Plain region, (2) pebble phosphate west of the Blue Ridge near Clifton Forge, and (3) dikes of nelsonite—a rock composed normally of a mixture of the minerals ilmenite and apatite occurring in Nelson and Roanoke counties.

The shell and greensand marls of the Coastal Plain region frequently carry a small but variable percentage of phosphoric acid. These marls are not rich enough, however, in phosphoric acid to render them of commercial value as a source of phosphate.

West of the Blue Ridge, the occurrence of phosphatic nodules has been observed at the base of Devonian black shale, at Clifton Forge, but the extent of this material is yet unknown.

The nelsonite dikes in Nelson County are numerous and extend over a considerable area. Much variation is shown in the mineral composition of the rock composing the dikes. Normally, the rock is a granular mixture of the minerals white apatite and black ilmenite in variable proportion. Either mineral may predominate over the other in quantity. Near Rose's Mill, the ilmenite of some of the dikes is largely or entirely replaced by rutile giving at times a rock composed essentially of apatite and rutile with little or no ilmenite. In the vicinity of Lovingston, some of the dikes are composed principally of magnetite and biotite with a variable amount of apatite, while others are made up almost entirely of apatite. Chemical analyses of the nelsonite, collected from dikes over different parts of the area, show the calcium phosphate to range as high as 33 per cent.

The occurrence of the rock nelsonite in this county has been known for many years, and it has been prospected in a small way by open pits, cuts, and shafts at a number of places, chiefly near Roseland, Bryant, Rose's Mill, and Lovingston. The development work in the nelsonite dikes, near Rose's Mill, by the General Electric Company, was for the mineral rutile and not for the phosphate mineral apatite.

The dikes of nelsonite in Nelson County represent the largest concentration of phosphatic material yet known in the State. These deposits have been studied and mapped in detail by the Virginia Geological Survey, and a bulletin setting forth the results at considerable length will shortly be published. Phosphatic rock, not unlike the nelsonite of Nelson County, occurs about four miles east of Roanoke, where considerable prospecting was done about seven years ago.

GRAPHITE.

Graphite is rather widely distributed through the Piedmont region, occurring chiefly in the schists and gneisses, but as yet no actual production of the mineral has been reported. The occurrence of graphite has been noted in the following counties: Albemarle, Amelia, Buckingham, Charlotte, Loudoun, Louisa, Nelson, Orange, and Powhatan.

Probably the most encouraging occurrence of the mineral is in the northern part of Albemarle County, between Free Union and Boonsville, near Buck Mountain. The graphite occurs here in irregular vein-like masses in gneisses and syenites and their residual decay. It is of good quality, and blocks weighing several hundred pounds are easily extracted. The Naylor-Bruce Graphite Company acquired the property several years ago and made some developments on it, but closed down within a short time without any production.

RUTILE (Titanium).

The only locality in the Atlantic States where rutile has been mined in quantity is in the Tye River-Hat Creek area of Nelson County. The area is a large one, located in the foot-hills region of the Blue Ridge, and is distant about 7 miles northwest of the main line of the Southern Railway. A second area of commercial rutile was discovered recently in Goochland and Hanover counties about 20 miles west and northwest of Richmond.

Two distinct types of rutile are mined in the Nelson County area. In the first type, designated pegmatite rutile, the rutile occurs chiefly as disseminated grains of variable size in an igneous rock of very coarse- to medium-grained crystallization of feldspars and blue

quartz with, in places, much hornblende. In the second type, designated nelsonite rutile, the rutile occurs in even-granular rocks, having dike-like characters, and composed normally of ilmenite and apatite. Near Rose's Mill, on Piney River, the ilmenite of the nelsonite is almost or entirely replaced at times by rutile, the rock ranging from an ilmenite-apatite mixture, in which little or no rutile is present, to a rutile-apatite mixture, containing but little ilmenite, with intermediate gradations in the ratio of ilmenite to rutile.

The American Rutile Company began mining the pegmatite rutile in 1901 from side-hill cuts along the east side of Tye River, a short distance below the entrance of Hat Creek, and, in 1902, a milling plant was built for concentrating the rutile. The rutile is very pure, of red to reddish brown color, and occurs chiefly as large and small grains, disseminated principally through the feldspar, but also in the blue quartz and the hornblende. The rutile is admixed in places with some ilmenite.

In 1907, the General Electrical Company began mining operations for rutile in the nelsonite dikes near Rose's Mill, about 7 miles northwest of Tye River post-office. After considerable prospecting had been done the rutile content of the dikes was found to be so irregular that work was abandoned in 1909. Hess reports that about 100 tons of rutile ore, carrying 50 per cent TiO_2 , were shipped which yielded 35 tons of concentrates. The nelsonite dikes in this locality carry large percentages of rutile in places—the dikes being composed almost entirely of rutile and apatite, the former predominating, but have been found to grade both laterally and vertically into the normal ilmenite-apatite rock.

The recently discovered (1909) deposits of rutile in the eastern portion of the Virginia Piedmont province, are grouped about several centers in the same general area in Goochland and Hanover counties. These are the Nuckols farm between Peers and Johnson's Springs and the Brown farm at Waldelock, Goochland County, and the Bowe farm on the north side of the South Anna River, near Gouldin, Hanover County. Some prospecting for rutile has been done on each of these farms. The country rock is a gneiss of variant composition, penetrated by pegmatite dikes that closely conform to the structure of the enclosing

gneiss. Both the enclosing gneiss and the pegmatites are usually deeply weathered. The pegmatite dikes show a somewhat marked foliated structure due probably to pressure effects chiefly. Rutile in very large quantity, ranging from fine grains to masses weighing several pounds, is scattered loose over the surface and in the soil. Masses of rutile weighing up to several hundreds pounds have been found on the Nuckols farm. More or less ilmenite is associated with the rutile and both occur as constituents of the pegmatite.

The rutile deposits of Virginia have been studied in detail by the Virginia Geological Survey, and a volume setting forth the results at considerable length will be published shortly.

According to Hess the total value of rutile concentrates produced in 1909 in the Nelson County area was estimated at \$10,000. The production of rutile in Virginia during 1910 was 556 short tons, valued at \$44,480.

LIST OF RUTILE (TITANIUM) OPERATORS

OPERATOR	OFFICE	MINE
American Rutile Co.	Washington, D. C.	Roseland
General Electric Co.	Schenectady, N. Y.	Rose's Mill
Myer, August	Richmond	Gouldin
Nuckols, A. C.	Peers	Peers

MINERAL WATERS.

The mineral waters of Virginia are an important source of revenue in the State. Virginia has a very large number of spring resorts, and a great variety and abundance of well-known commercial waters. Virginia is second only to New York in the number of springs that are utilized commercially, and exceeds New York in the number of resorts.

All classes of mineral waters are found in the State, and some of these are among the most celebrated in the country. They are naturally divided into (1) those containing mineral salts in such proportion as to give them medicinal value, and (2) those approximately pure waters which are sold extensively for table or domestic use.

The production of mineral waters for 1909, exclusive of 83,254 gallons used in the manufacture of soft drinks, was 1,504,530 gallons, valued at \$203,455, these figures representing a decrease from the

production during the previous year, of 595,084 gallons in quantity, and \$3,660 in value. It will be observed that, while there was such a marked decrease in the quantity of mineral waters sold during 1909, the value lacked only \$3,660 of equalling that of the previous year. This is due to an increase in the average price per gallon of the water sold, the average price in 1909 being 14 cents per gallon as against 10 cents per gallon in 1908.

The production of mineral waters in Virginia during 1910 amounted to 2,441,923 gallons, valued at \$301,523. These figures, which are exclusive of 48,252 gallons used in the manufacture of soft drinks, represent an increase over the 1909 production, of 937,393 gallons in quantity, and \$98,068 in value. The average price per gallon of the water sold during 1910 was 12 cents.

The following table gives the production and value of mineral waters in Virginia from 1903 to 1910, inclusive.

Production and Value of Mineral Waters in Virginia, 1903 to 1910.

Year	Springs reporting sales	Quantity sold Gallons	Value
1903	41	2,561,502	\$ 477,410
1904	35	2,117,420	281,998
1905	37	2,340,287	589,102
1906	43	1,997,207	418,908
1907	44	2,442,075	431,770
1908	46	2,099,614 ^a	207,115
1909	49	1,504,530 ^a	203,455
1910	40	2,441,923 ^a	301,523

^aAmount used for soft drinks not included.

Of the \$203,455 worth of mineral waters sold in Virginia during 1909, \$102,296 worth was sold for medicinal purposes and \$101,159 worth for table or domestic use. The total number of springs reported as producing in 1909 was 49, as against 46 in 1908. These were distributed among the following 26 counties: Albemarle, Alexandria, Amelia, Augusta, Bath, Botetourt, Campbell, Chesterfield, Culpeper, Frederick, Henrico, Isle of Wight, Loudoun, Mecklenburg, Montgomery, Norfolk, Nottoway, Prince Edward, Roanoke, Rockbridge,

Rockingham, Surry, Sussex, Tazewell, Warwick, and Wythe. Several of the springs reported resorts, with total accommodations for 3,518 people, and eight reported bathing establishments.

Of the 1910 production of mineral waters, valued at \$301,523, \$153,633 worth was sold for medicinal purposes and \$147,890 worth for table or domestic use. The total number of springs reported as producing in 1910 was 40. These were distributed among the following 23 counties: Alexandria, Amelia, Augusta, Bath, Botetourt, Campbell, Chesterfield, Culpeper, Franklin, Frederick, Isle of Wight, Loudoun, Mecklenburg, Montgomery, Nottoway, Prince Edward, Roanoke, Rockbridge, Rockingham, Surry, Sussex, Tazewell and Wythe. Several of the springs (11) reported resorts, with total accommodations for 2,105 guests.

Out of a total of 63 mineral springs credited to Virginia, 40 reported sales during the year 1910. The list of springs follows, with those producing in 1910 marked by an asterisk (*).

- *Alexandria Well, Alexandria, Alexandria County.
- *Alleghany Spring, Alleghany Springs, Montgomery County.
- *Basic Spring, Basic City, Augusta County.
- *Bath Alum Springs, McClung, Bath County.
- *Bear Lithia Spring, near Elkton, Rockingham County.
- *Beaufont Spring, Beaufont, Chesterfield County.
- *Bellfont Lithia Spring, Manchester, Chesterfield County.
- Berry Hill Mineral Spring, near Elkwood, Culpeper County.
- *Blue Ridge Springs, Blue Ridge Springs, Botetourt County.
- Brugh's Spring, near Nace, Botetourt County.
- *Buckhead Lithia Springs, Buckhead Springs, Chesterfield County.
- *Buffalo Lithia Springs, Buffalo Lithia Springs, Mecklenburg County.
- *Burnett's Mineral Spring, Hudson Mill, Culpeper County.
- *Campfield Lithia Spring, Temples Station, Chesterfield County.
- *Carper Lithia Springs, Radford, Montgomery County.
- Como Lithia Spring, East Richmond, Henrico County.
- *Coppahaunk Lithia Springs, Waverly, Sussex County.
- *Crockett Arsenic Lithia Spring, Crockett Springs, Montgomery County.

- *Days Point Artesian Lithia Spring, Smithfield, Isle of Wight County.
- Diamond Spring, Diamond Springs Station, Princess Anne County.
- *Erup Mineral Spring, Glencarlyn, Alexandria County.
- *Falling Springs, Falling Springs, Augusta County.
- Farmville Lithia Springs, Farmville, Prince Edward County.
- *Fonticello Lithia Spring, near Richmond, Chesterfield County.
- *Harris Anti-Dyspeptic Spring, Burkeville, Nottoway County.
- *Holly Lithia Springs, three miles east of Richmond, Chesterfield County.
- Houston Chlorated Spring, Houston, Halifax County.
- *Iron-Lithia Springs, Tiptop, Tazewell County.
- *Jeffress Lithia Silica Spring, Jeffress, Mecklenburg County.
- *Jordan White Sulphur Spring, Jordan Springs, Frederick County.
- *Kayser Lithia Springs, Staunton, Augusta County.
- *Lone Jack Spring, Lone Jack Station, Campbell County.
- Magee's Chlorinated Lithia Spring, Clarksville; Mecklenburg County.
- Manganese Sodium Iodide Spring, Hallsboro, Chesterfield County.
- Massanetta Spring, Harrisonburg, Rockingham County.
- *Mecklenburg Mineral Springs, Chase City, Mecklenburg County.
- Mulberry Island Spring, Mulberry Island, Warwick County.
(Name changed to Chloride Lithia Spring).
- *Nye Lithia Springs, Wytheville, Wythe County.
- O'Connell Lithia Spring, Stribling Springs, Augusta County.
- Otterburn Lithia Spring, Amelia, Amelia County.
- *Pæonian Springs, Pæonian Springs, Loudoun County.
- Pantops Mountain Spring, 3 miles east of Charlottesville, Albemarle County.
- Paradise Spring, Clifton Station, Fairfax County.
- *Pickett Spring, Worsham, Prince Edward County.
- Powhatan Spring, Ballston, Alexandria County.
- Roanoke Lithia Spring, two and one-half miles west of Roanoke, Roanoke County.
- *Rockbridge Alum Springs, Rockbridge Alum Springs, Rockbridge County.

- *Rocky Mount Lithia-Magnesian Spring, Rocky Mount, Franklin County.
- *Rubino Healing Springs, Rubino Healing Springs, Bath County.
- *Seawright Magnesian Lithia Spring, Staunton, Augusta County.
- Shenandoah Alum Springs, Shenandoah Alum Springs, Shenandoah County.
- Smithfield Artesian Well, Smithfield, Isle of Wight County.
- *Stribling Springs, near Mount Solon, Augusta County.
- *Tripho-Lithia Spring, Claremont, Surry County.
- Trois Fontaine Lithia Spring, South Hill, Mecklenburg County.
- *Virginia Etna Springs, Vinton, Roanoke County.
- Virginia Lithia Springs, Osceola, Chesterfield County.
- *Virginia Magnesian Alkaline Spring, near Staunton, Augusta County.
- Virginia White Rock Springs, Mount Solon, Augusta County.
- *Wallawhatoola Springs, near Millboro Spring, Bath County.
- Waterlick White Sulphur Spring, Waterlick, Warren County.
- White Oak Mineral Spring, Norfolk, Norfolk County.
- *Wyrick Mineral Spring, near Wytheville, Wythe County.

PRECIOUS STONES.

A variety of minerals of gem grade has been found in the crystalline rocks of the Piedmont province of Virginia. Some counties in this area, which seemingly offer good possibilities for the occurrence of gem material, have not yet been exploited for this purpose. The known counties which have either produced gem materials, or contain minerals which might be of desirable gem grade, are Amelia, Amherst, Bedford, Buckingham, Fairfax, Hanover, Nelson, and Spotsylvania. Of these, Amelia County is the best known and has produced the largest variety and quantity of gem material. This material has come from the mica mines opened in the pegmatite dikes near Amelia Courthouse.

Those minerals known to occur in Virginia which have been used, or are probably capable of being used, for gem material are quartz including several varieties, garnet including several varieties, allanite, kyanite, fluorite (chlorophane), feldspar including several species, microlite, apatite, beryl, turquoise, columbite, and helvite. Although

these minerals occur in Virginia not all of them have been found to be of gem grade.

The value of the production of precious stones in Virginia for 1909 was \$2,500. There was no reported production of precious stones in Virginia during the year 1910.

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